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Pollen Analysis and Taphonomy of Localtity 15 Alluvial Sediments, Old Crow Basin, Yukon

by

Keary Walde

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF Master of Arts

Department of Anthropology

EDMONTON, ALBERTA

Spring, 1986

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Pollen Analysis and Taphonomy of Localtity 15 Alluvial Sediments, Old Crow Basin, Yukon submitted by Keary Walde in partial fulfilment of the requirements for the degree of Master of Arts in Paleoenvironmental Anthropology.

Charles Schweger

Supervisor

Alan Tyler Bryan

Date October 23, 1985

Abstract

The Old Crow Basin, northern Yukon, contains alluvial and lacustrine deposits of pre-Late Wisconsinan provenience. These fossiliferous deposits are accessable at many bluff exposures along the Old Crow River. A paleoecological assessment was completed on a 27.00m sediment profile from the Locality 15 section on the Old Crow River. Palynological and sedimentological techniques were employed for this assessment. In addition, taphonomic analyses were completed on a number of problems inherent to alluvial palynology. These included, a) a study on the relationship between pollen concentrations, preservation and degradation within various sediment categories, and b) the testing of 8 hypotheses on the relationship between silt content and pollen concentrations of selected taxa.

These analyses permitted valuable insights into the plaeoecological history of the basin that could not be accomplished by conventional pollen analysis. Data obtained indicate that alluvial palynolopgy can be a viable means by which to conduct paleoecological research.

Pollen data indicate a number of cycles existed within the basin between forest and tundra conditions from Late Illinoian times to ca. 28,000 years ago. The presence of Early Carboniferous spore in the upper 6.00m of sediment is most suggestive that paleofluvial discharge may have been diverted westward in Alaska from the Richardson Mountains during probable Mid Wisconsinan times. This in turn could be indicative that Laurentide Ice may have blocked the McDougall Pass during this time period. The presence of these spores, if utilized to extrapolate paleofluvial direction, necessitates the re-evaluation of the current hypothesis on regional drainage and glacial history in the region during Mid to Late Wisconsinan times.

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To the many individuals who assisted my endeavours during field research, laboratory analysis and writing of this thesis, I would like to extend my most deepest appreciation. Special thank yous to those members of the Yukon Refugium Project who made the field research in the Old Crow Basin, a memorial chain of events, including; Dick and Heather (the Heater) Morlan, John Matthews Jr., Owen Hughes, Nat Rutter, and, of course, my supervisor, Charlie Schweger. To the people of Old Crow, especially the Charlies, I will always appreciate their friendship and hospitality. To Alan Bryan, more special thank yous for editorial assistance during the final drafting of this thesis. Partial funding was provided by the Boreal Institute for Northern Studies. I would like to thank them for this assistance. Finally, to those co-students who offered a gleam of humour and intellectual discourse during the final peparation of this thesis, many more thank yous, especially to the individual with the shoelaces of many colours.

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I. Introduction

A. Introduction

During periods of glaciation the greater portion of the Yukon Territory, Canada, remained ice-free and formed the eastern province of a region commonly known as Beringia (Figure 1.1). As it remainined unglaciated, Beringia served as an extensive refugium for plants and animals (Hulten 1937, Hopkins 1967). Also, it has been long considered that the first human groups to enter the North American continent must have occupied this region at some point during the Late Quaternary. In the Old Crow Basin (Figure 1.2), as well as many other localities in the Yukon, Alaska and Asia, fossil deposits of Pleistocene megafauna attest to the mammalian richness of the Beringian landscape (Harington 1977, Péwé 1975). Although the Old Crow fossil deposits have been known since the early 1900s it was not until the mid 1960s that their archaeological significance became evident. On July 10, 1966, David Lord, a Vanta Kutchin [1] Indian from the village of Old Crow, employed as guide and field assistant to Dr. C. R. Harington, vertebrate paleontologist, National Museum of Natural Science, Ottawa, uncovered a fossilized caribou tibia from a modern pointbar on the Old Crow River at a collecting site designated Locality 14N (Figure 1.2). The distal end of the tibia was expertly modified into what appeared to be a fleshing tool. Like other mineralized bones recovered from the same deposit which included elements from extinct Pleistocene megafauna, the flesher was deeply stained. A date, derived from the bone apatite fraction, of 27,000 ±2000-3000 (GX 1640) apparently confirmed the artifact's antiquity.[2] Two proboscidian long bone fragments from the same deposit were similarly dated at 29,100 ± 2,000-3000 (GX 1567) and 25,750±1800-1500 years B.P. (GX 1568) (Irving and Harington 1973). Although the bone flesher and associated fossils were recovered from a modern point bar, these dates plus the

---

[1]Vanta Kutchin is an Athabascan name meaning "The people of the Lakes". These people are a subgroup of the Loucheux Indians who occupy this region (Leechman 1954)

[2]It is ironic that this flesher which was one of the most significant factors in establishing two interdisciplinary research projects in the Old Crow Basin, was recently redated at ± 2,000 years B.P. (Edmonton Journal, 27 September, 1985).

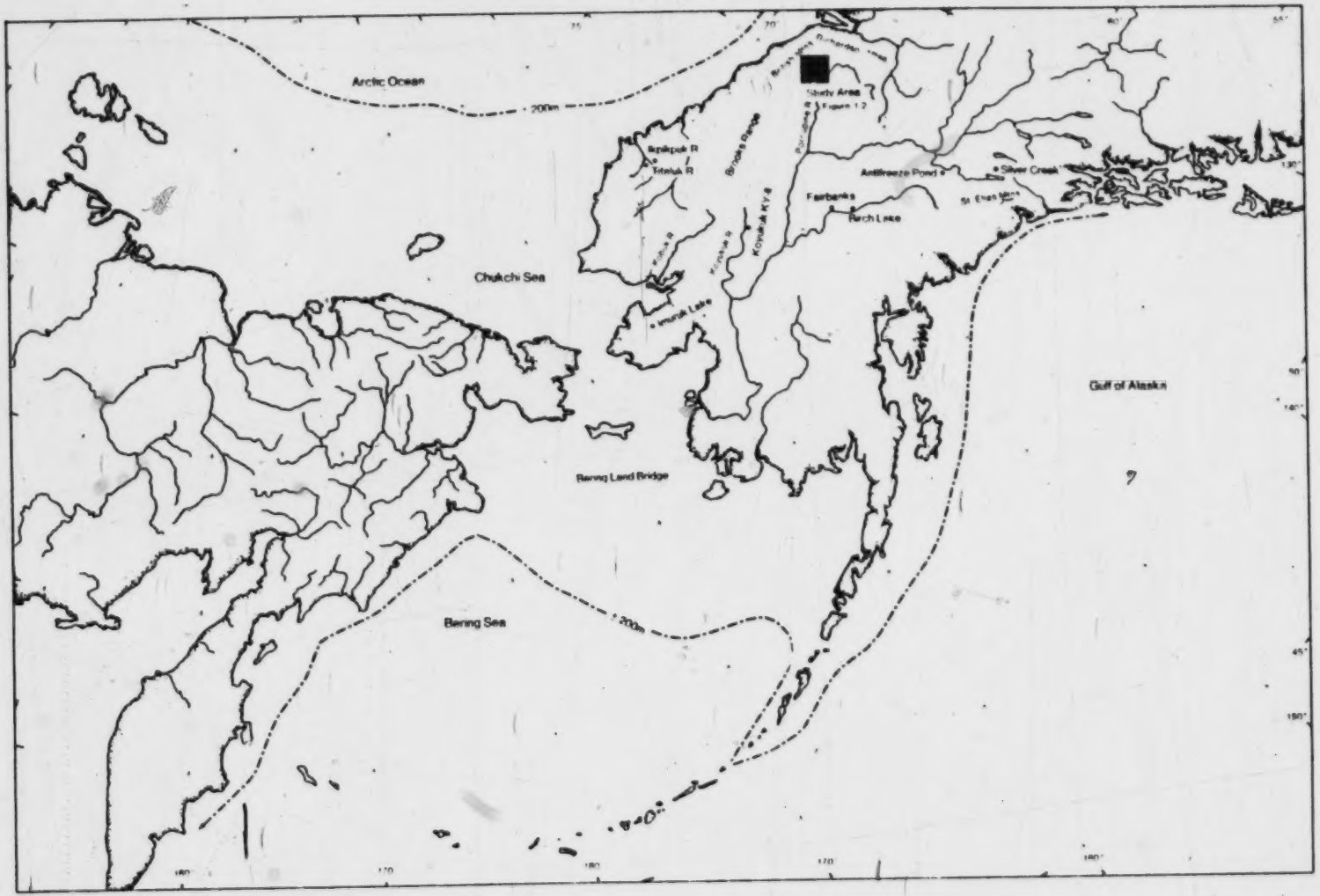

Figure 1.1 Location map of research study area and other localities mentioned in the text

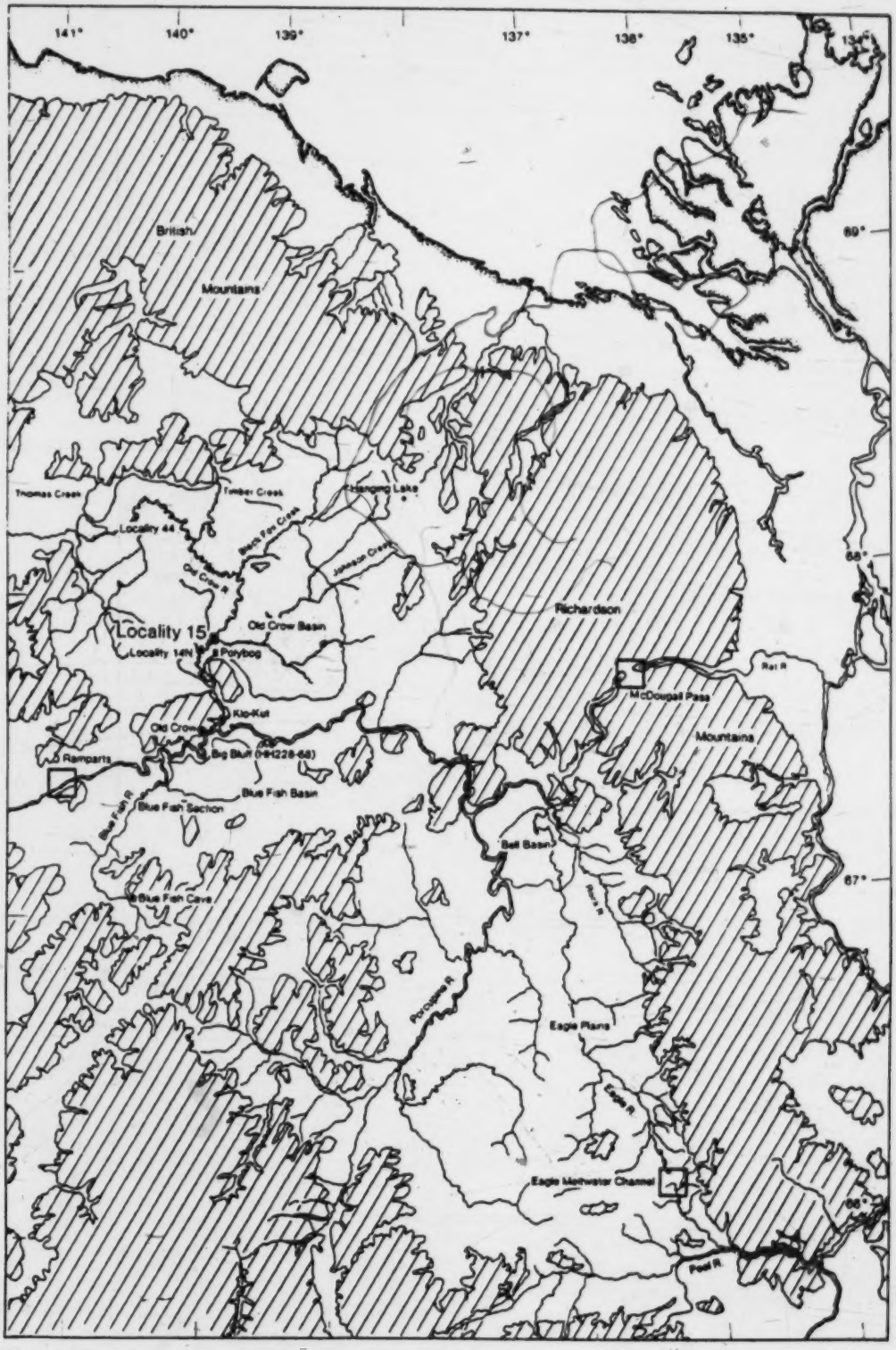

Figure 1.2: Research study area and adjacent site localities mentioned in text.

similar staining characteristics suggested the possible presence of human populations contemporaneous with extinct megafauna within the Old Crow Basin during the Late Quaternary. This discovery, plus the general lack of knowledge concerning early human occupation, geology and paleoecology of the nothern Yukon refugium, led to the establishment in 1974 of the Yukon Refugium Project (YRP) by Dr. R. E. Morlan, National Museum of Man in Ottawa. Included within the project were personnel from the Geological Survey of Canada and the University of Alberta, Departments of Anthropology and Geology (Morlan 1981).

Following the first two years of exploratory field reconnaisance it was concluded that alluvial bluffs along the river systems were the best localities for obtaining the requisite data for their research goals. It was argued that intensive study of selected bluffs may uncover undisturbed evidence for Late Quaternary human occupations and furthermore provide necessary data on the geology and paleoecology for this region. Locality 15 on the Old Crow River (67°51'N, 139°48'W: Geological Survey of Canada designation HH 68-9, Archaeological Survey of Canada designation MlVl-2) was one of a number of alluvial sites selected for detailed description, sampling and analysis (Figure 1.2). The study carried out for this thesis was conducted at Locality 15 as apart of the paleoecological goals of this project.

Although paleoecological reconstructions have been obtained with pollen data collected from alluvial sections in the Yukon, Alaska and elsewhere (cf. below), some criticism of alluvial palynology is present in the literature. Ritchie and Cwynar (1982:117) believe that the reworking of pollen-bearing alluvial sediments destroys the lithostratigraphic and chronostratigraphic provenance which in turn prohibits the placement of the pollen assemblages within a temporal framework. They recommend that pollen for paleoecological analysis must be obtained from undisturbed sites. Unfortunately in the northern Yukon, as well as elsewhere, such preferred sites dating to pre-Late Wisconsinan times are not accessable or they do not exist. Consequently alluvial sections have to be considered important sites for conducting paleoenvironmental research. Alluvial sections are often unique as they frequently offer for study a cross-section of preserved sedimentary features sometimes covering several kilometers.

Such features include cut-and-fill sequences, pointbar deposits (foreset beds), overbank deposits (topset beds), lacustrine deposits (ponds, ox bows), soil horizons, ice wedge pseudomorphs and autochthonous peat deposits. In addition, fossilized bone, tephra, detrital organics as well as shrubs, trees and shells, some still in growth position, are associated with many of these features (Schweger 1982: 95-96). Together with the fossil pollen record these features provide considerable data for paleoenvironmental reconstruction.

B. Thesis Objectives

Three research objectives were delineated for study in this thesis. These included:

1. The primary and overall objective of this thesis was to attempt to further our understanding of the pre-Late Wisconsinan paleoecology of the Old Crow Basin through the use of fossil pollen and sedimentological analyses.

2. The second objective included the study of the pollen-bearing characteristics of the sediments present at the Locality 15 site.

3. The third objective included the study of preservation characteristics of the fossil pollen.

The purpose of the second objective was to assertain if certain pollen taxa differentially became incorporated within silts of a fluvial suspension load as published in Catto (in press). Eight hypotheses were constructed for testing. These are presented in Chapter 6. The purpose of the third objective was considered significant because previous research, as reviewed below, has demonstrated that different classes of deterioration preserved on the fossil pollen are indicative of certain taphonomic processes. The results of these analyses should be a valuable interpretive aid in the evaluation of the pollen diagram and in the assessment of alluvial sediments for paleoecological reconstructions. By combining these objectives in one study, a greater understanding of the site paleoecology may be realized and will, in turn, permit a greater understanding of the vegetational and climatic history of the Old Crow lowlands.

C. Literature Review

Pollen Taphonomy

Many problems inherent to alluvial palynology are related to taphonomic variables affecting pollen production, dispersal, deposition and subsequent preservation within a sedimentary environment, which in turn is affected by a host of geographical and fluvial variables. Various research studies have shed some light on these parameters. The composition of pollen assemblages is influenced to a high degree by the type of catchment basin(lacustrine or alluvial), composition of vegetation, the geography of the area (in-basin, side-basin, montane) and prevailing wind direction.

Pollen can also be lost either before reaching an appropriate catchment basin by predepositional factors such as wind or vegetative barriers (Tauber 1965, 1967), or after deposition by factors such as low amounts of sporopollenin in the pollen's exine (Sangster and Dale 1961, 1964; Havinga 1964, 1971), microbiological attack (Elsik 1966, 1971), chemical degeneration (Brooks and Elsik 1974), fungi growth (Goldstein 1960) or consumption by insects (Fægri and Pijl 1966:40). Studies conducted into relationships between deposition and degradation of pollen grains in various environments include: Troels-Smith (1941), Cushing (1964, 1966), Birks (1969, 1970), Andersen (1976), King et al. (1975), Bonny (1976, 1978), Pahlsson (1977), Bradshaw (1978), Delcourt (1979). In reference to fluvial systems Tschudy (1969) notes that the deposition of pollen will be affected by sediment particle size, shape, density, coagulability, and the physical condition of the site of deposition. Once pollen grains or other palynomorphs are deposited, on for example, a fluvial surface, it is necessary for the grains to 'break' through the water surface (Brush and Brush 1972). Certain pollen characteristics, e.g., bladders, would tend to keep the grain buoyant for a longer period of time in a non- turbulent system. It is a common assumption that pollen grains, once submerged, will behave in the same manner as mineral particles within the fine silt/clay size range and will therefore be most abundant within sediments of these size classes (Groot 1966:409). A recent

study by Catto (in press) on the hydrodynamic distribution of playnomorphs in a fluvial environment is dependent upon their specific gravities, which will cause them to become incorporated within silts. Catto suggests that, a) pollen from arboreal and arboreal-shrub genera are preferentially deposited in medium silt, b) *Picea* and Ericaceae pollen are most likely to be deposited along with medium to fine silt, c) *Betula* and *Alnus* pollen are most likely to be deposited with medium to fine silt. These three suggestions are tested as hypotheses in Chapter 6.

Cushing recognized that the condition of the exine can be used to assess taphonomic processes involved in the deposition and preservation of pollen in sediments. He recognized six preservation classes: a) corroded, b) degraded, c) crumpled and exine thinned, d) crumpled but exine normal, e) broken, f) well preserved. Various researchers have since used his system in their pollen analyses (Birks 1970, 1977, Bradshaw 1978, Delcourt and Delcourt 1980). Certain problems occur when using this system (Birks 1970:812). If, for example, a pollen grain contains a number of these classes, only the highest class is recorded. Consequently many attributes which may be taphonomically significant are ignored. Such constraints have led various palynologists (e.g., Delcourt and Delcourt 1980) to modify this system with additional categories. The processes responsible for pollen deterioration and their preserved features are noted on Table 1.1.

Synchroneity of pollen dispersal and fluvial discharge rates may also play an important part in the pollen-bearing capabilities of alluvial sediments. Research by Ritchie (1977:412) on the Mackenzie River Delta indicates that the flowering season for anemophilous plants (*Salix, Populus, Betula, Picea,* Gramineae and Cyperaceae is restricted to only five weeks, from ±12 June to 20 July with heavy airborne shedding occurring between 14 June to 1 July. All flowering is complete by early August and no local pollen is discharged into the air after the third week of July. Hydrological data collected from the Old Crow River from 1976 to 1981 by Environment Canada at their collection station # 09FC001 upstream from the confluence of

the Porcupine River[3] indicates that spring breakup usually occurs in May and flooding peaks by mid June. By the end of July to the following April the discharge rate is very low. The beginning of heavy airborne pollen dispersals will coincide with the peak and waning of fluvial discharge. It could be expected, therefore, that if fluvial discharge rates are high and coincide with pollen dispersal, there will be a strong possibility that most of the pollen will be transported farther down stream than under lower energy conditions. It is also possible that once pollen becomes incorporated within a suspension load in can be transported over long distances if the right velocity is maintained.

Sediments will likely pick up previously deposited pollen and incorporate them along with fresh pollen grains. If palynomorphs were obtained from extremely ancient sediments, they may be discoloured due to oxidation and other thermal conditions. Where specific palynomorphs, e.g., pre-Quaternary spores, are found in a sample, and if they occur only at certain localities, it should be possible to infer a source for the sediment and possible changes in fluvial direction when they are present in the sediment.

In overview, it may be concluded that a pollen assemblage preserved in an alluvial deposit is the net result of a continuum of interrelated parameters that include:

1. Local versus regional composition of various original vegetation communities, e.g. in-basin, side-basin, montane and extraneous.

2. Plant propagation strategies creating differential pollen rains.

3. Differential amounts of sporopollenin in the pollen exine which leads to variable preservation in different pollen types.

4. Physiographic characteristics of the catchment basin.

5. Physiographic characteristics of the fluvial system and composition of sediment load.

---

[3]Written communication, Environment Canada, Water Resources Branch, Inland Waters Directorate, Pacific and Yukon Region, 502- 1001 West Pender St., Vancouver B.C., V6E 2M9 (1983)

6. Synchroneity of peak fluvial run-off versus peak periods of pollen production and release.

7. Direct or indirect pollen deposition into the fluvial system.

8. Retransportation and redeposition of previously deposited pollen assemblages of varying ages.

Palynology Research in the Study Area

In the Yukon and Alaska, many lake basins, caves and alluvial exposures have been exploited for their palynological resources (Figure 1.1 & 1.2). Dated deposits include: Blue Fish Caves, ca.13,000 B.P. (Cinq-Mars 1979); Tungak Lake, >14,000 years; Lake III (Puyuk Lake, Saint Michael Island), >15,000 years (Ager 1982); Birch Lake, ca. 15,000 years (Ager 1975); Hanging Lake, ca. ±25,000 years (Cwynar 1979); Antifreeze Pond, ca. 31,000 years (Rampton 1971) and Kvichak Peninsula, >33,000 years (Ager 1982). Peatlands also contain excellent Holocene records as well, e.g., the Birch Lake area (Ager 1975) and Polybog in the Old Crow Basin (Overden 1982). Imuruk Lake, studied by Colinvaux (1964), Colbough (1968) and Shackleton (1979), is unique as it contains early Wisconsinan deposits with an extrapolated age of ca. 100,000 years B.P., as determined by the Imuruk Lake Core 5 (Shackleton 1979), which contains Old Crow tephra dated between 87,000 - 115,000 B.P. (Schweger & Matthews n.d.). The Old Crow tephra is a very significant stratigraphic marker for regional paleoenvironmental comparison as it is now recognized at several localities within the Old Crow Basin including Locality 15, the Blue Fish Basin at the Big Bluff Site (G.S.C. designation HH228-68), the Koyukuk River Basin and the Fairbanks area (Westgate et al. 1983; Schweger and Matthews n.d.).

Fossil pollen data thus far studied from alluvial sections of pre-Late Wisconsinan provenience include sites in the Old Crow and Blue Fish basin (Lichti-Federovich 1973, 1974; McCort 1982); along Hungry Creek, Bonnet Plume Basin (Hughes et al. 1981); in the

Fairbanks area (Matthews 1974); sections along the Kobuk River (Schweger 1976); Koyukuk River (Schweger, n.d.); Silver Creek, St. Elias Mountains (Schweger and Janssens 1980); Ikpikpuk and Titaluk River (Nelson 1982); and Kvichak Peninsula (Ager 1982).

II. Old Crow Basin

A. Physiography and Climate

The Old Crow Basin, covering ca. 6,500 km², is one of four structural depressions occupying the Porcupine Plain (Bostok 1948). The remaining three, the Blue Fish Basin, Bell Basin and the Eagle Plain are located to the south (Figure 1.2). The Old Crow Basin is situated south of the British Mountains and west of the Richardson Mountains. General evelation of the flats lies below 300m a.s.l. and the uplands range between 300 and 600 m. Plateaus adjacent to the British Mountains are ca. 900m a.s.l. (Oswald & Senyk 1977:70). A mosaic of shallow rectangular thermokarst lakes, up to 6 km across, are present. Patterned-ground development is also a common phenomenon as the basin lies within the region of continuous permafrost (Brown 1977). The basin is drained by the Old Crow River and its tributaries; Timber, Black Fox, Johnson and Schaeffer Creeks. The Old Crow River has cut through the underlying Pleistocene sediments to a depth of ca. 30 m.

The climate is continental with a January mean of -36° C and a July mean of 14.° C. Precipitation is low: ca. 19.2cm per annum, of which 9.2cm falls during June-August (Oswald & Senyk 1977:15).

B. Bedrock and Surficial Geology

The bedrock geology has been described by Norris (1963), Douglas and Maclean (1963), Mountjoy (1967a & b), Lenz (1972) and Miall (1973). Surficial geology is described in Hughes (1969, 1972). Additional data on Pleistocene stratigraphy is reported in Morlan (1978, 1980), Morlan and Matthews (1980), Hughes et al.(1981) and Thorson and Dixon (1983). Nine stratigraphic units are recognized within the Old Crow Basin. These include (after Morlan 1980):

1. Unit 1: Clays, massive, some vertical jointing present and oxidized, non-fossiliferous. Interpreted as glacio-lacustrine of probable Illinoian age; surface probably exposed to drying and aerobic weathering.

2. Unit 2: Clays, reworked, small channels sometimes present along contact with Unit 1 sediments contains fossil bone concentrations. Interpreted as reworked glacio-lacustrine (Unit 1) representing a period of downcutting and erosion of lake bed in late Illinoian or early Sangamon times.

3. Unit 3: Sands, silts and clays, bedded, lateral facies changes and vertical changes are common, cut and fill structures containing bone and plant fossils at some locations, ice wedge pseudomorphs present along erosional contact with Unit 4, volcanic ash present just below erosional contact. Interpreted as representing alluviation during Sangamon and/or early Wisconsinan times. Erosional contact designated 'Disconformity A', volcanic ash designated 'Old Crow Tephra'.

4. Unit 4: Silts, fine sands, cross-bedded, sediments disturbed at some locations. Fractured bones and plant fossils present along erosional contact with Unit 3. Interpreted as mid-Wisconsinan in age, and possibly human occupation. Disturbed sediments considered to be cryoturbation features.

5. Unit 5: Silts, fine sands, cross-bedded, disturbed features near contact with Unit 6, autochthonous peats occur, fossil bones present. Interpreted as late Wisconsinan in age.

6. Unit 6: Clays, varved, non-polleniferous. Interpreted as glacio-lacustrine and late Wisconsinan in age. Represents lake deposits present in the basin throughout the classic Wisconsinan.

7. Unit 7: Silts, sands, channel fill, remains of **Bison crassicornis** present (Locality 12). Interpreted as early post-glacial, caused by the draining of glacial lake ca. 12,000 years ago.

8. Unit 8: Floodplain deposits. Interpreted as Holocene in age, alluviation following downcutting by the modern Old Crow River through underlying sediments (Units 1 - 7).

9: Unit 9: Sand and silt bars on modern Old Crow River, contains deposits of retransported Pleistocene and Holocene vertibrate fossils. Modern.

The interpretation of these units is noted in Hughes (1969, 1972). He suggests that the Porcupine River originally flowed northeast through the McDougall Pass. During at least two glacial advances (Illinoian? Late Wisconsinan), McDougall Pass was blocked by Laurentide ice causing the ancestral Porcupine River to flow westward. This resulted in the creation of glacial lakes within the Old Crow and Blue Fish Basins (Unit 1). Strandlines from these lakes are

recorded up to the ±1200 foot (365m) contour line (Hamilton n.d.). Following the first deglaciation cycle the river was re-established through McDougall Pass. Alluvial sedimentation continued to fill these basins (Units 3, 4 & 5) until ca. 28,000 years ago when McDougall Pass was again blocked with glacial ice. Until ca. 12,000 years ago, glacial lakes occupied the the Old Crow and adjacent basins (Unit 6). Following deglaciation, the draining of these lakes (Unit 8) created an outlet channel through the Ramparts (Figure 1.2) at a lower elevation than McDougall Pass, and a permanent westward flow of the Porcupine River was established. No evidence for an Early Wisconsinan glacial advance was recorded (Hughes 1976). However this evidence is at variance with data obtained by Thorson and Dixon (1983) on the Porcupine River in Alaska west of the Ramparts, and by Rampton (1982) from the north slope of the British Mountains. Data from alluvial sediments below the Ramparts indicate that a westward discharge occurred at least three times during the mid to late Wisconsinan. The early discharge (± 40,000 - ±35,000 years B.P.) and the later discharge (±20,000 - ±15,000 years B.P.) represented high energy environments while the middle episode (±30,000 years B.P.) appeared to be low energy (Thorson and Dixon 1983). Rampton (1982) argues that Laurentide ice reached the Richardson Mountains during mid-Wisconsinan times (±50,000 years B.P>), which he calls the Buckland Glaciation. These data suggest that the history of fluvial discharge and blockage through the Richardson Mountains was more complex during mid to late Wisconsinan times than previously thought.

C. Modern Vegetation

Modern plant studies in the Old Crow region includes Cywnar (n.d.), Welsh and Rigby (1971) Wein et al. (1974), and Oswald and Senyk (1977). The area is presently characterized by boreal forest, forest tundra, shrub tundra and montane tundra. and is designated as the Old Crow Ecoregion by Oswald and Senyk (1977:68). The northern extension of the tree-line passes through the northern part of the basin. The Old Crow flats are characterized by open stands of black spruce on poorly drained surfaces with some white spruce on better drained soils. Stands

of white birch are present at some locations. The shrub zone includes species of birch, willow and alder. Sedge meadows and heaths constitute the open ground cover. On the lower valley slopes a closed forest of white and black spruce occurs. At higher elevations a birch-heath shrub tundra, occurs while on the summits and altiplanation surfaces, discontinuous ground cover is dominated by species of *Dryas* and *Salix*.

D. Locality 15 Site

Locality 15 (Fig. 2.1) is located on the west bank of the Old Crow River 1 km upstream from the Johnson Creek confluence. The exposure is 1 km long and ca. 34m high. Retrogressive thaw flow slides have eroded the upper 6m, leaving 27m of sediments exposed on the main facet. Locations of stations along the main facet are noted on Figure 2.1 (rear jacket).

III. Research Methodology

A. Introduction

Data collection was limited to the main facet of Locality 15 and includes Units 2 through 6 as discussed in Chapter One. Unit and station designation mentioned below follow those used by Morlan (1980). Collection stations and general bluff characteristics are illustrated on Figure 2.1 (rear jacket). The majority of the sediment samples were collected from Stations 3 and 7 during the 1978 field season. The two stations are located adjacent to each other and are divided by an erosional gully. The same stratigraphic units are clearly discernable at each station thus permitting accurate cross-referencing.

B. Field Methods

In the field the sediment was cleaned back to ca. 100cm to expose undisturbed deposits and to insure that no contamination by modern pollen occurred. Sampling proceeded vertically from water level at Unit 2, Station 3 into the glaciolacustrine deposits of Unit 6, Station 7, on the main facet of the exposure. Samples of 100g were collected and sealed in whirlpac bags. Disconformity A, at 19.00m above river level (June 28, 1978), was used as a main reference feature for lateral orientation of features described at other stations.

In Unit 3, samples were collected every 50cm. In Units 4, 5 and 6, sampling was done at 20cm intervals. Where specific features were noted additional samples were collected. Also, a number of samples were obtained from along the disconformity and from various ice wedge pseudomorphs and other features at the different stations (cf., Fig. 4.7, Part A, rear jacket).

Samples were stored frozen in the laboratory prior to processing.

C. Laboratory Methods

The preparation and analysis of the data is outlined in the research flow diagram, Figure 3.1 (rear jacket). Each component is discussed below.

Sample Size

Sediment samples were divided, 50g each for grain size and pollen analysis (Fig. 3.1). Smaller sample weights were used with peats and highly organic sediments.

Grain Size Analysis

In order to prepare the data for sedimentological description and taphonomic analysis with the palynological data the following procedures were followed. Sample processing followed the method outlined in the Glacial Geology Field and Laboratory Manual, Department of Geology, University of Alberta (n.d.). Particle size distributions were plotted using a Fortran program developed by Dr. R. May, of Ron May & Associates Ltd., Edmonton. Ternary textural classification followed Trefethen (1950) while particle sizes were classified into Phi(Ø) units after Wentworth (Folk 1974). For plotting purposes the clay fraction was divided into 'coarse clays' (>8<9 Ø) and 'fine clays' (>9 Ø). Sediment clast morphology was studied using a Scanning Electron Microscope (SEM), in the Department of Entomology, University of Alberta. General grain morphology from each sample was recorded. Description of visual roundness followed Powers (1958) and visual sphericity followed Rittenhouse (1943), cf. Shackley (1975). Other visual characteristics, e.g., solution diagenesis, silica precipitation and breakage, followed Krinsley and Doornkamp (1973) and Whally (1978).

Palynological Analysis

Fifty gram samples were processed according to the heavy liquid method in use in the Paleoenvironmental Laboratory, Department of Anthropology, University of Alberta and outlined in Schweger (1976). The processed organic residue was suspended in 300 microlitres

(μl) of silicone oil, 2,000 centistrokes as recommended by Andersen (1960) and Fægri and Iversen (1975). Volumetric control was maintained using Dade disposable pipettes, type II glass ± .5 % accuracy. The purpose of suspending the residue within a known volume of oil was to establish a comparable pollen concentration for each sediment sample which could then be expressed as 'Pollen Concentration per 300μl per 50g of sample weight'.

In preparing slides for counting, the 300 μl sample was thoroughly mixed for 3 minutes. A 25 μl sample was then extracted by pipette and mounted on a 25 x 75mm. slide. Residue remaining in the pipette was flushed out with acetone and added to the slide sample. After evaporation of the acetone, a cover slip was added and sealed with clear nail polish.

A Leitz SM-Luc binocular microscope with 10x periplan occulars was used for counting. Routine counting was completed with a 40x NPL fluorite objective with a numerical aperture of 0.70. A 100x NPL oil immersion objective (numerical aperture 1.30) was utilized where critical assessments were required.

The pollen sum was a minimum of 200 identifiable pollen grains. [4] Arboreal pollen (AP), Non-Arboreal pollen (NAP) and Aquatics/ Semi-aquatic pollen were included in the sum. If a 200 pollen sum was not achieved from one slide, additional slides were counted from the same sample. If a sum was obtained at a mid point on a slide, the remaining portion of the slide was counted and included in the final sum. This was done in order to ensure continuity between samples of pollen concentration per volumetric sample size. Where pollen grains were only partially visible within the field of vision, only those grains in the upper hemisphere were recorded. If the slide contained fewer than 40 grains, that sample was classified as sterile. Percents for palynomorphs outside of the pollen sum were obtained by adding the number of the particular grains to the pollen sum and then dividing the combined sum by the number of grains in question.

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[4]In 3 samples less than 200 grains were obtained

Pollen Identification

Pollen and spore identification were checked with the aid of the reference slide collection maintained by the Paleoenvironmental Laboratory, Anthropology Department, University of Alberta, and with available keys (Fægri and Iversen 1975, McAndrews et al. 1973, Habgood, n.d.). Pre-Quaternary spores were identified where possible from McGregor and Camfield (1982), Barss (1967), Playford (1962). Additional assistance was received from Dr. J. Utting, Institute for Sedimentary and Petroleum Geology, G.S.C., Calgary, who kindly identified specific pre-Quaternary miospores.

Computer tabulated, 215.5x35.5mm data recording forms were used to record palynomorphs and attributes during counting. Data recorded from each sample were stored on computer tape for later analysis.

Pollen Preservation Coding Index

A preservation coding index, modified from Cushing (1966) and Delcourt and Delcourt (1980), was implimented in order to record all morphological characteristics preserved on all palynomorphs (Appendix A). This was required from the completion of Thesis Objective 3. This index is divided into two units, a) Taxon Coding Index and b) Preservation Index.

Taxon Coding Index

All palynomorphs are given a code number in one of six categories, a) trees and large shrubs (001-099), b) small shrubs and herbs (100-199), c) aquatics & semi-aquatics (200-299), d) Pteridophyta and algae (300-399), e) forms, other (400-499) and f) unidentifiable palynomorphs (500-599). Each taxon was given a coding number within its applicable category.

In some taxa, a sequence of code numbers were allotted to a specific taxon, e.g., Pinaceae (001-007) for the purpose of recording individual bladders (004), body with one bladder (005), etc. To achieve a pollen sum, two separate bladders (004) or one body with

bladder (005) were later counted as one pollen grain.

Preservation Index

Morphological characteristics discernable on each palynomorph were further classified under three variables, namely, a) phenotypic category, b) exine condition, and c) grain colouration.

Phenotypic Categories

In this category a palynomorph was recorded according to its observable condition. Grains were classed as either, a) normal, b) folded, c) perforated, d) split and combinations among the last three categories. Within Cushing's system, folded is comparable to crumpled, perforated to corroded and split to broken.

Exine Condition

Because exine condition is variable on fossil palynomorphs it was deemed necessary to recorded this variability. Consequently, the grains' exines were recorded as either, a) excellent, b) good and c) poor.

Grain Colouration

It was noted that fossil palynomorphs exhibit variability in colouration under normal illumination. Distinct ranges, when observed, were therefore indexed. Eight ranges were recorded (Appendix A). Pollen colouration was obtained by comparing the individual grain, under normal microscopic illumination, with the Revised Standard Soil Colour Chart (Oyama and Takehara 1970).

Unidentified Palynomorphs

Unidentifiable pollen grains were categorized within one of three classes, namely, a) Unidentifiable Pollen, b) Indeterminable and c) Unknown.

Unidentifiable: Code 500-504

The unidentifiable pollen category is similar to Cushing's indeterminable/deteriorate class, e.g., pollen exines were so deteriorated they could not be identified with any degree of certainty. Category classes are as noted in Appendix A.

Indeterminable: code 550

The indeterminable pollen class (code 550) differs from Cushing (op cit.) in that it only applies to grains concealed by detritus on a slide sample.

Unknown: Codes 574-577

Unknown pollen types follow Cushing (op cit.), i.e. the pollen grain is well preserved but its taxon level cannot be ascertained due to lack of reference material. These were indexed as either, a) unknown triporate, b) unknown tricolporate (TCP), c) unknown palynomorph and d) unknown tetrad.

Unidentifiable Spores

Where spores could not be identified they were recorded as either, a) Alete (Code 310), b) Monolete (Code 312) and c) Trilete (Code 313). All unidentified forms observed during counting were also coded.

IV. Sedimentological Results and Interpretation

A. Introduction

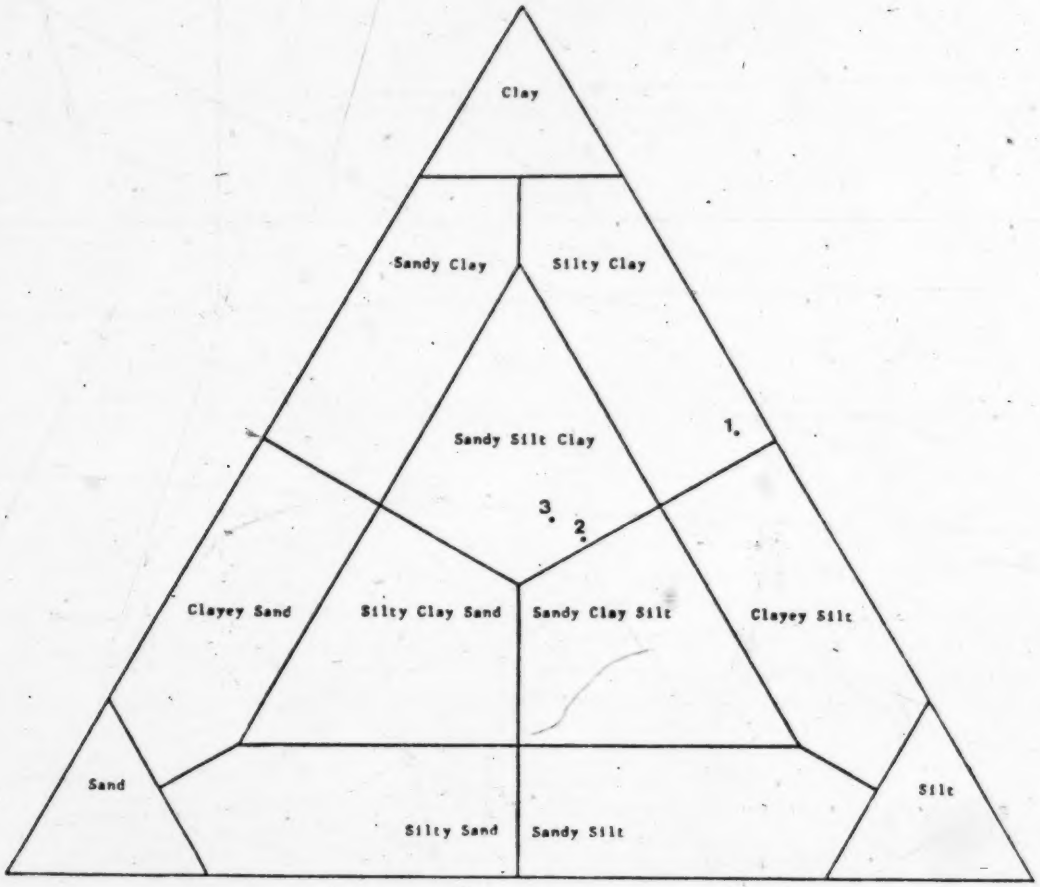
Grain size analysis was completed on 63 samples from Stations 3 and 7. These results are presented on Ternary diagrams (Fig. 4.1-4.5) and the mean sediment classifications are compared (Fig. 4.6). Photographs of grain morphology, as noted from Scanning Electron Microscopic (SEM) observations, are presented in Plates 4.1-4.8. Note that the scale in the lower lefthand corner is in microns. All sedimentological research results are summarized on Figure 4.7 (rear jacket). This figure is divided into three parts, a) stratigraphic positions of features at selected stations, b) unit designations, stratigraphy and clast morphology and c) relative percent diagram containing Wentworth size categories.

During SEM observation it was noted that the morphology of the sediment grains was variable but corresponded well with the unit designations. As Unit 3 contained 17.85m of sediment and distinctive changes in grain morphology were common, it was decided, for the purpose of taphonomic analysis and pollen zonation, to divide this unit into 7 subdivisions (a - f). It should be noted however that these divisions are not discernable in the field and are included here solely for the purposes just mentioned.

Conchoidally fractured grains within the coarse silt and fine sand fractions were recorded at various elevation during S.E.M. observations. X-ray diffraction signatures are high in silica indicating quartz rich lithics. The significance of these broken clasts are discussed separately at the end of the chapter. Research results and interpretation for each unit are presented below.

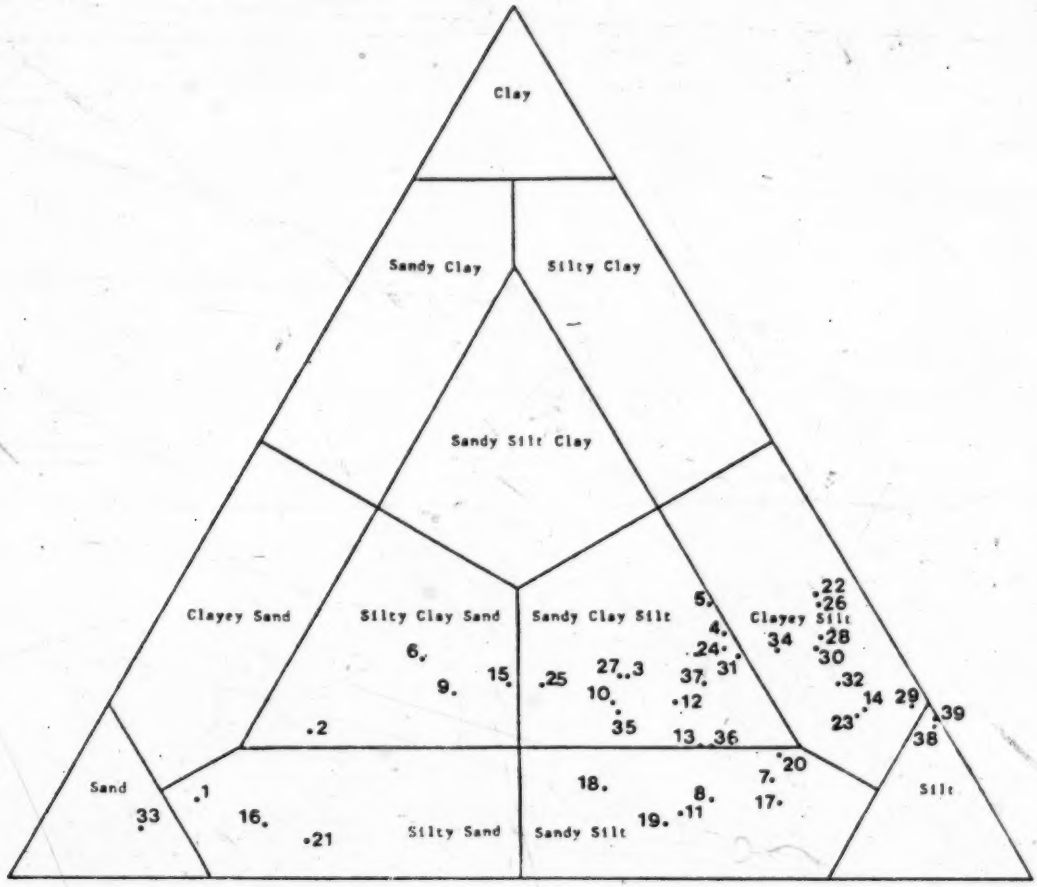
B. Unit 2(0.00m - 1.15m)

Sediments are compact with no visiable bedding present. Contact with Unit 3 is disturbed. Textural classification ranges from sandy silt clay to silty clay (Fig. 4.1), with a mean texture of sandy silty clay (18%-39%-43%). The dominant size class is fine clay (Fig. 4.7,



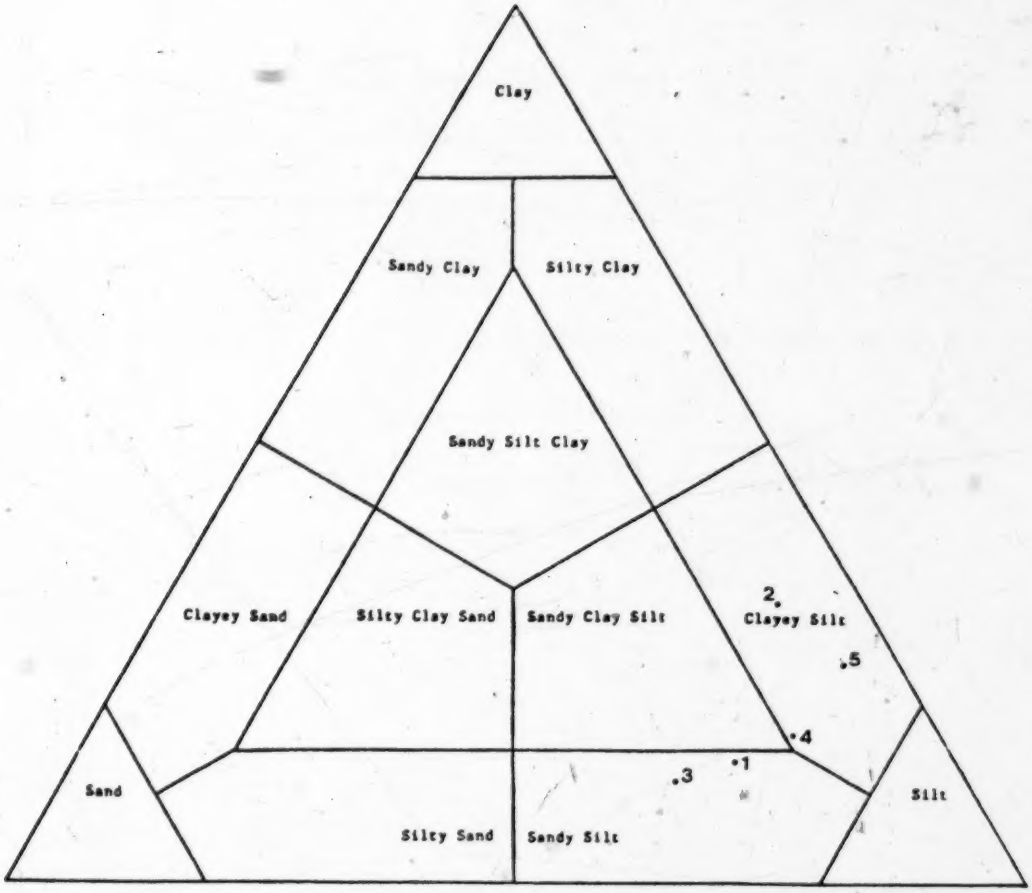
1:0.00m(03-46-51)
2:1.10m(26-33-41)
3:1.15m(24-37-39)

Figure 4.1:Ternary Diagram of Unit 2 Sediments (%Sand-%Silt-%Clay)



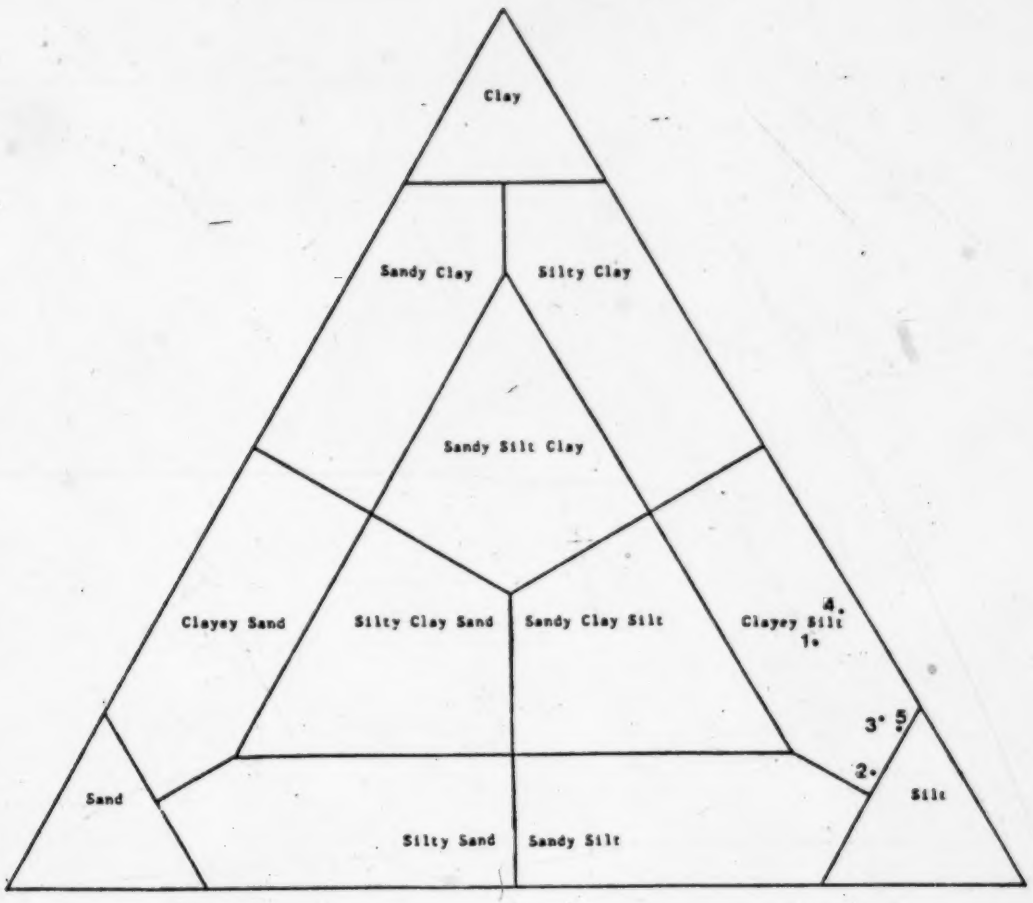
1:1.40m(77-14-09)
2:1.67m(62-21-17)
3:2.20m(28-49-23)
4:2.55m(16-56-28)
5:3.35m(16-53-31)
6:3.55m(47-28-25)
7:3.67m(20-69-11)
8:4.50m(27-64-09)
9:5.00m(46-33-21)
10:5.50m(31-59-20)
11:6.00m(31-62-07)
12:7.00m(25-55-20)
13:7.45m(25-60-15)
14:8.00m(07-74-19)
15:8.50m(40-38-22)
16:9.50m(72-22-06)
17:10.00m(21-71-08)
18:10.50m(37-53-10)
19:11.00m(33-61-06)
20:11.30m(18-68-14)
21:11.68m(69-27-04)
22:12.00m(05-63-32)
23:12.30m(08-74-18)
24:12.60m(17-57-26)
25:13.00m(37-41-22)
26:13.50m(05-64-21)
27:14.00m(29-48-23)
28:14.50m(07-66-27)
29:15.00m(02-79-19)
30:15.50m(08-66-26)
31:16.00m(16-59-25)
32:16.50m(08-70-22)
33:16.76m(84-10-06)
34:16.81m(12-62-26)
35:17.00m(31-50-19)
36:17.30m(24-61-15)
37:17.50m(21-57-22)
38:18.00m(01-82-17)
39:18.50m(00-82-18)

Figure 4.2:Ternary Diagram of Unit 3 Sediments(%Sand-%Silt-%Clay)



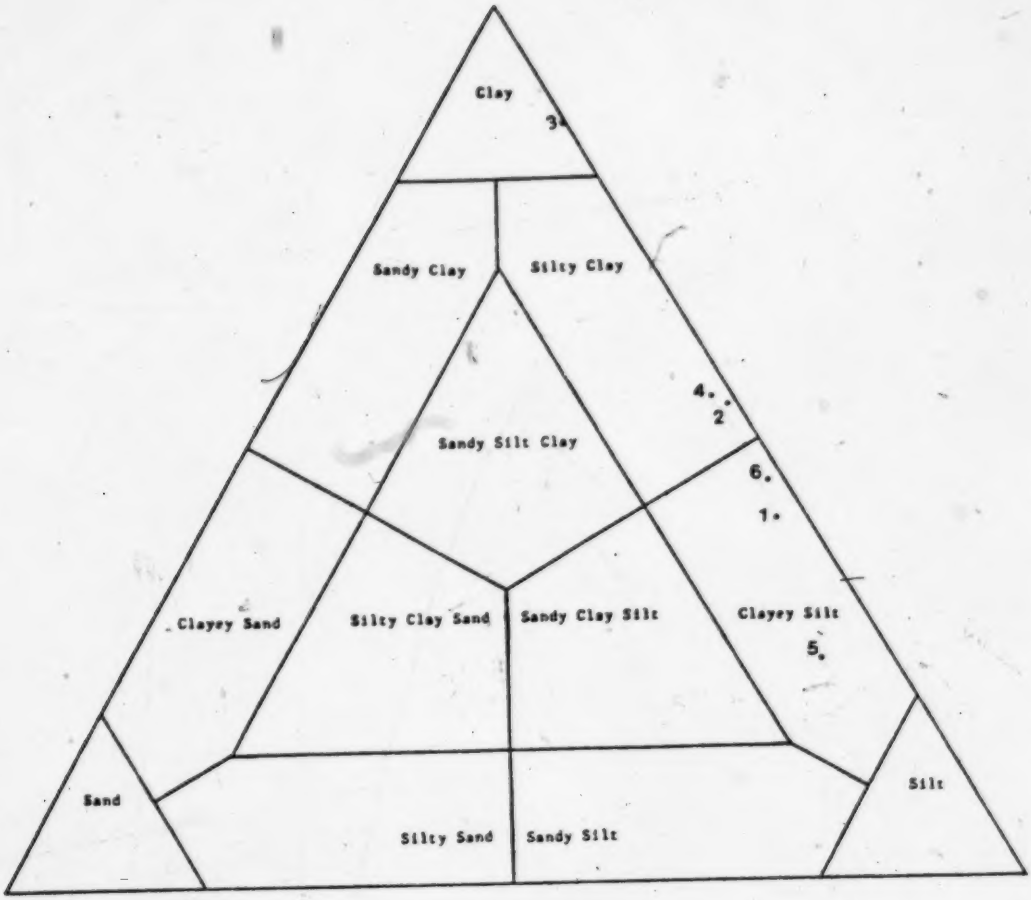
1:19.00m(16-65-19)
2:19.40m(08-60-32)
3:19.80m(28-60-12)
4:20.20m(14-69-17)
5:20.80m(05-70-25)

Figure 4.3:Ternary Diagram of Unit 4 Sediments (%Sand-%Silt-%Clay)



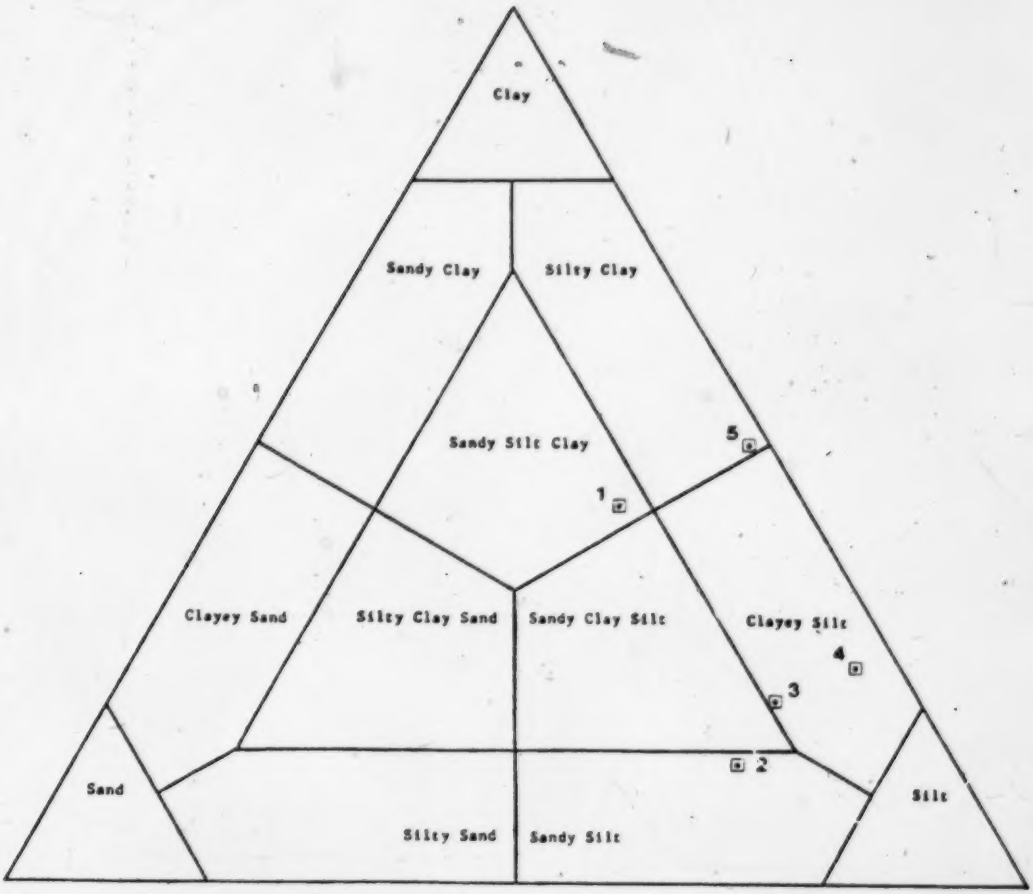
1:21.20m(07-65-28)
2:21.80m(08-79-13)
3:22.20m(04-77-19)
4:22.70m(02-67-31)
5:23.40m(02-77-21)

Figure 4.4:Ternary Diagram of Unit 5 Sediments (%Sand-%Silt-%Clay)



1:23.60m(01-56-41)
2:24.40m(01-45-54)
3:25.00m(00-14-86)
4:25.30m(02-43-55)
5:25.55m(07-68-25)
6:25.60m(02-53-45)

Figure 4.5:Ternary Diagram of Unit 6 Sediments (%Sand-%Silt-%Clay)



1:Unit 2(18-39-44)
2:Unit 3(27-54-19)
3:Unit 4(14-65-21)
4:Unit 5(04-71-25)
5:Unit 6(02-48-50)

Figure 4.6:Ternary Diagram of Unit Sediment Means (%Sand-%Silt-%Clay)

Part C, rear jacket). Other important classes include very fine silt, coarse silt and coarse clay. Sand becomes more common near the Unit 3 contact.

Clast morphology is noted in Plate 4.1a. Clasts are subangular with spherecity values ranging between .75 and .77 and roundness values ranging between .1 and .3 (Fig. 4.7, Part B, rear jacket). There is evidence for solution diagenesis and silica precipitation (Plate 4.1a&b) as well as edge erosion (Plate 4.1c). A number of grains have also been fractured. Conchoidal breakage is common (Plate 4.1d, e & f) on some grains. Of special interest are, a) the 'bulb of percussion' (Plate 4.1e) and b) blade-like flake (Plate 4.1f). Unit sediments are interpreted as reworked glacio-lacustrine.

C. Subdivision 3a(1.15m - 3.35m)

Foreset bedding occurs to ca. 2m. Bedding above this elevation is horizontal but poorly defined. Fossils of wood, plant and faunal remains, including **Mammuthus primigenius** are present along the disturbed contact with Unit 2. Sediments are the coarsest for the entire section ranging from silty sand, silty clay sand to sandy clay. Mean texture is silty clay sand (46%-35%-19%), (Fig. 4.7, Part B, rear jacket). Fine and very fine sands predominate in the lower portion of the unit but gives way to coarse and medium silts above 2.20m (Fig. 4.7, Part C, rear jacket).

The clasts are generally subangular to subrounded in appearance (Plate 4.2a). Sphericity ranges between .75 to .77 while roundness ranges between .1 to .3 (Fig. 4.7, Part B, rear jacket). Conchoidally fractured grains are common (Plates 4.2b, c & d). An excellent example of a percussion bulb with concentric ripples is noted in Plate 4.2c. These flakes are fresh in appearance although subsequent edge erosion occurs on some examples (Plate 4.2e). On this particular example note the edge erosion plus the precipitation of silica on the surface. On grains that have not been subjected to conchoidal fracturing, solution diagenesis appears to be well developed (Plate 4.2f).

Plate 4.1: Unit 2 sediment grain characteristics

a. Unit 2: General morphology.

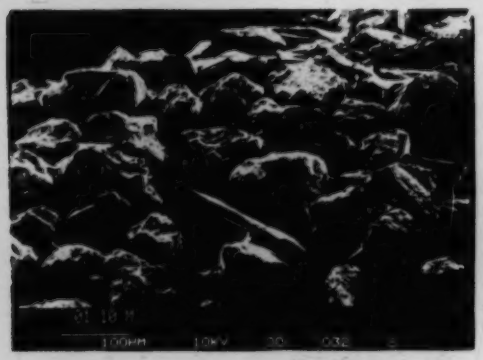
b. Unit 2: General morphology.

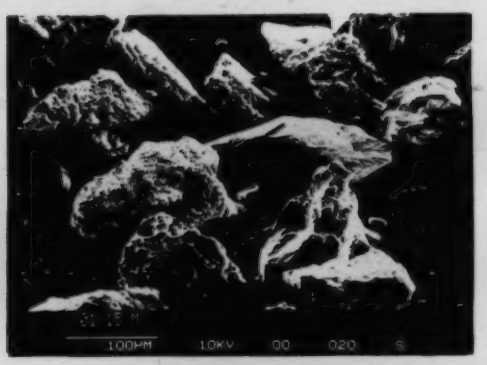
c. Unit 2: Example of grain erosion.

d. Example of conchoidal breakage.

e. Unit 2: Example of a conchoidally fractured 'geo-microflake'.

f. Unit 2: Example of a conchoidally fractured 'geo-microblade'.


100μM 10KV 00 032 S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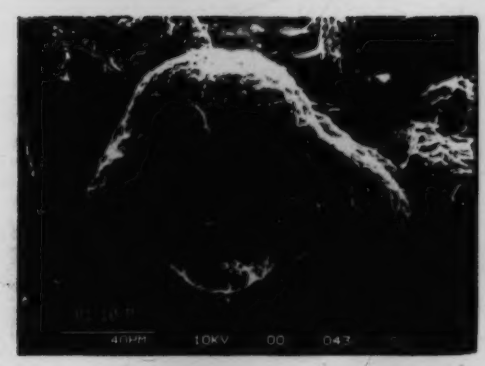
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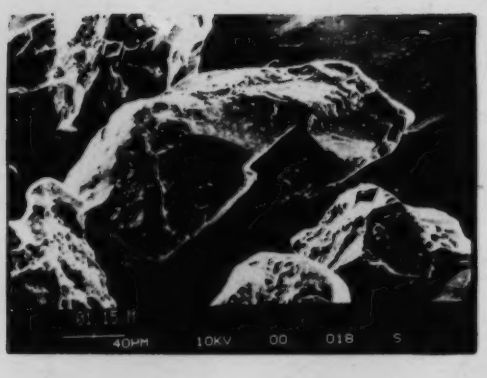
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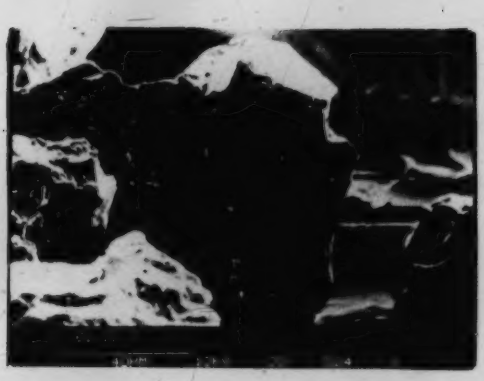


Plate 4.2: Subdivision 3a sediment grain characteristics

a. Subdivision 3a: General morphology of sediment grains.

b. Subdivision 3a: Example of conchoidal breakage.

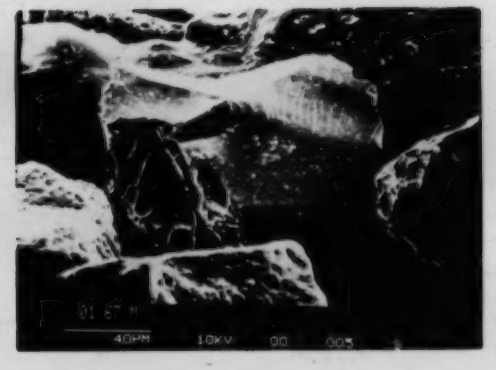
c. Subdivision 3a: Example of 'geo-microflake' with bulb of percusion and concentric rings.

d. Subdivision 3a: Example of a 'geo-microblade'.

e. Subdivision 3a: Conchoidally fractured grain with subsequent erosion.

f. Subdivision 3a: Example of solution diagenesis.

200µM 10KV 00 010 S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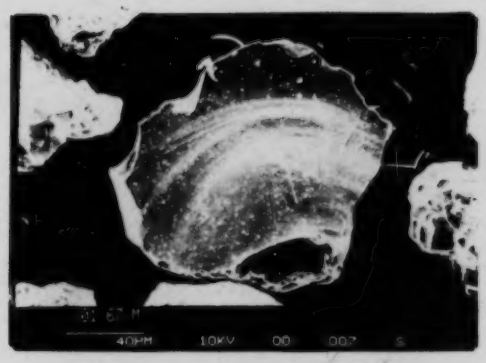
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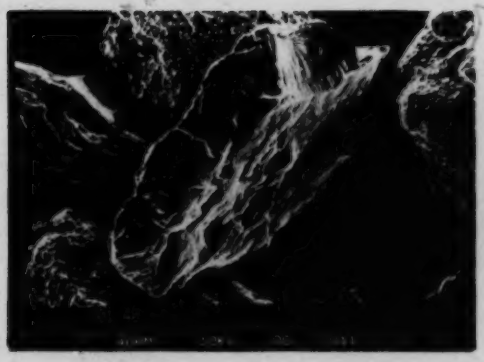
40µM 10KV 00 008 S



100µM 10KV 00 026 S

A number of tephra-like shards were noted (Plate 4.3a). X-ray diffraction signature of these shards indicates that they are a K Feldspar (Plate 4.3b). Comparisons were made to shards from the Old Crow and Ltlle Timber Tephras (Plate 4.3c, 4.3d, 4.3e and 4.3f) which are present within the Old Crow Basin. The Old Crow Tephra is present at Station 2, Locality 15 while the Little Timber Tephra is from Locality 47 and 94 on the Old Crow River in the northwestern part of the basin. The signature is most comparable to that of the Old Crow Tephra. This subdivision is interpreted as a portion of an alluvial point bar. The presence of the tephra-like shards may indicate an older ash fall from the same source as the Old Crow tephra.

Subdivision 3b(3.35m - 7.45m)

This subdivision is horizontally well bedded. Some cross-beeding occurs. Thin laminae of peaty detritus and shells are common throughout. Wood fragments are present in the lower sediments. Sediments are much finer than the preceeding subdivision. The texture classifications for this unit range from clay silt, clayey silt, silty clay and silty sand with a mean texture of sandy clay silt (30%-52%-18%), (Fig. 4.7, Part B, rear jacket).

Medium sand is common below 5.00m while fine sand is fairly important throughout. Fine clays increase in dominance above 5.00m. The clasts are subangular to blocky in appearance (Plate 4.4a). The subrounded clasts that were characteristic to subdivision 3a disappear in this unit. Sphericity values decrease while roundness values increase (Fig. 4.7, Part B, rear jacket). concohoidal breakage is still present (Plate 4.4b). Solution diagenesis and silica precipitation appears to be present. This subdivision is interpreted as alluvium laid down in a low energy environment.

Unit 3c(7.45m - 10.00m)

Sediments are horizontally bedded sands, silts and clays containing organic detritus. Larger fossils of wood and faunal remains are also present. The sediment textural classifications range from clayey silt, silty clay sand to silty sand with a mean texture of

Plate 4.3: Comparison of a possible tephra shard with known tephra.

a. Subdivision 3a: Example of tephra-like shard.

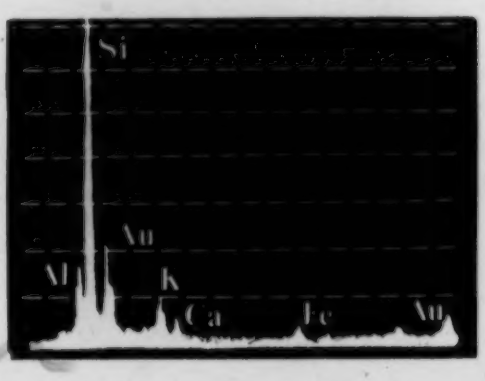
b. X-ray diffraction signature of (a).

c. Eample of an Old Crow tephra shard from Station 3.

d. X-ray diffraction signature of (c).

e. Example of a Little Timber tephra shard.

f. X-ray diffraction signature of (e).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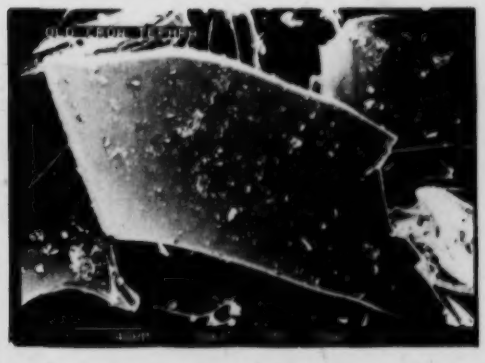
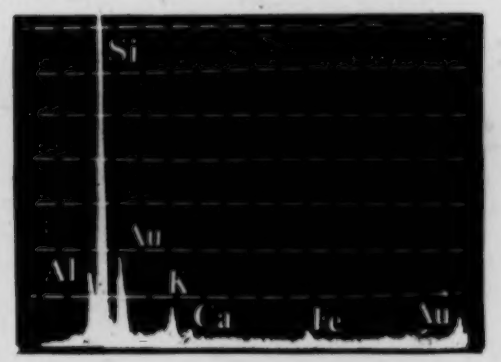
Al
K
Ca
Fe
Au

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Al
K
Ca
Fe
Au

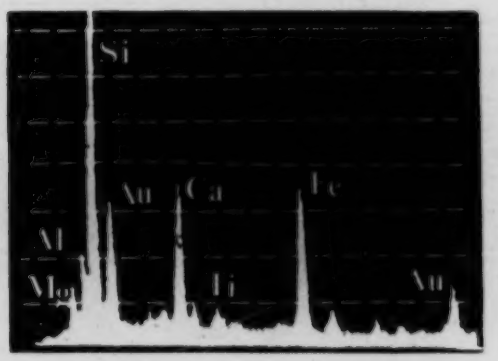

Si
Au
Ca
Fe
Al
Mo
Ti
Au

Plate 4.4: Subdivisions 3b & 3c sediment grain characteristics

a. Subdivision 3b: General morphology.

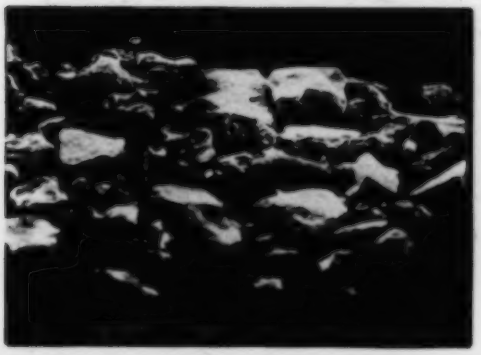
b. Subdivision 3b: Example of conchoidal breakage.

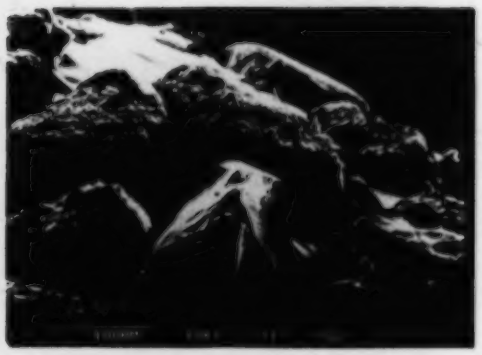
c. Subdivision 3c: Example of a well rounded grain.

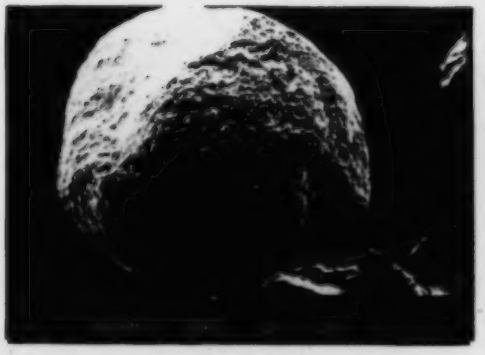
d. Subdivision 3c: Example of blocky morphology.

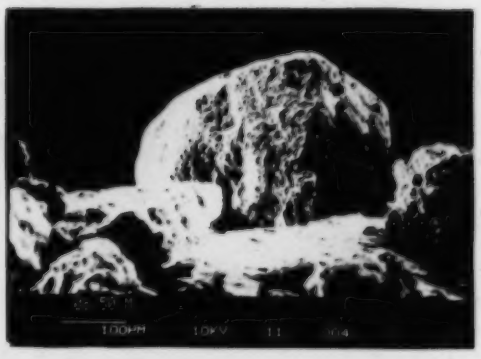
e. Subdivision 3c: Example of conchoidal breakage.

f. Subdivision 3c: Fractured grain with subsequent erosional features.








100nm
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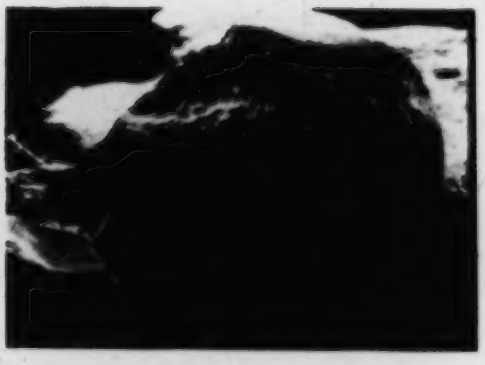


between sandy silt and sandy clay silt (36%-49%-15%), (Fig. 4.7, Part B, rear jacket). This unit is slightly more sandy than the preceding Subdivision 3b (Fig. 4.7, Part C, rear jacket). Coarse, medium and fine silts plus fine clay are most common below 8.50m. At this elevation the sediment becomes coarser with medium, fine and very fine sands predominating. The clasts are significantly more rounded (Plate 4.4c) and blockier (Plate 4.4d) in appearance than those noted in the lower sediments. Sphericity ranges between .91 and .97 and roundness values range between .4 and .5. Some grains also exhibit a roundness of .9 (Fig. 4.7, Part B, rear jacket).

A number of grains are broken (Plate 4.4e) or flaked (Plate 4.4f). Conchoidal breakage is both relatively fresh (Plate 4.4e) and eroded (Plate 4.4f). Of interest is a possible broken 'sponge spicule' within the 9.00m deposit (Plate 4.5a). The surface of this spicule has been subjected to erosional forces similar to the majority of the sediment grains within this subdivision. Both silica precipitation and solution diagenesis are present. This subdivision is interpreted as alluvium deposited under a slightly higher energy environment than the preceeding subdivision. Fossil concentrations may represent fluvial lag deposits.

Subdivision 3d(10.00m - 16.00m)

Sediments are predominently silts. Cross-bedding at a slight angle of repose occurs from 10.00m to 14.00m. Above 14.00m bedding planes become horizontal and thicker in nature. Ostracod fossils are present in the lower sediments. Fine organic detritus is common throughout the upper sediments.

Textural classification of this unit ranges from sandy silts, silty sands, clayey silt to sandy clay silt with a mean texture of sandy clay silt (21%-60%-19%), (Fig. 4.7, Part B, rear jacket). Coarse and medium silts are the dominant clasts (Fig. 4.7, Part C, rear jacket). Very fine sand is also important, especially below 12.00m. Fine sand is common within a number of samples. Clays and the finer silts become more common above 12.00m (Fig. 4.7, Part C, rear jacket). The clasts are subangular to subrounded (Plate 4.5b & 4.5c). Two ranges of sphericity are noted. A dominant category with values between .91 and .95 and a less dominant group

Plate 4.5: Subdivisions 3c, 3d & 3e sediment grain characteristics

a. Subdivision 3c: Possible broken spunge spicule.

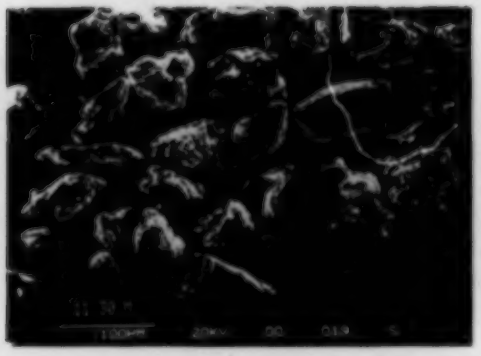
b. Subdivision 3d: General morphology.

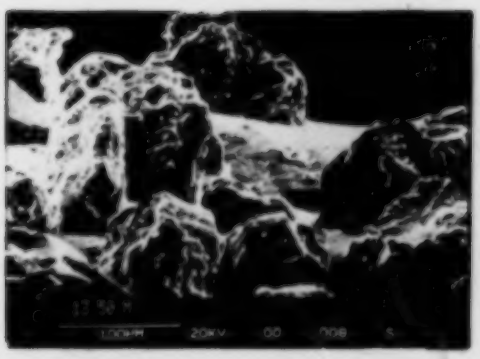
c. Subdivision 3d: General morphology.

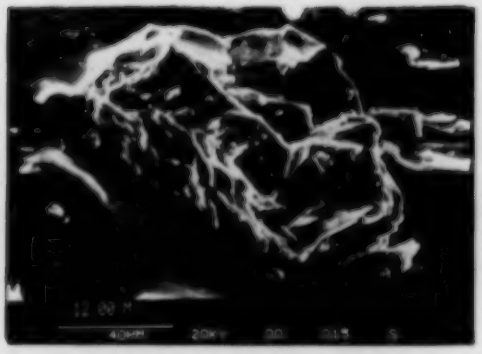
d. Subdivision 3d: Example of 'step' breakage.

e. Subdivision 3d: Example of subsequent erosion on broken grains.

f. Subdivision 3e: General morphology.







with values of .57 to .59. Roundness values range between .1 and .3 (Fig. 4.7, Part B, rear jacket). Grain breakage is characteristically blocky in nature (Plate 4.5d). Thin conchoidally fractured grains are absent. Solution diagenesis and silica precipitation appear to be common and all edges exhibit a fairly high degree of wear and rounding (Plate 4.5e). This subdivision is interpreted to be alluvium, probably representing a uper sedimentation within a point bar sequence.

Subdivision 3e(16.00m - 17.50m)

Sediments are horizontally bedded silts with some sands and clays. Bedding planes are narrow and very compact. Interbedded laminae of peaty detritus are present throughout.

Texture classification ranges from sandy clay silt, clayey silt, sand to sandy silt with a mean texture of sandy clay silt (28%-53%-19%), (Fig. 4.7, Part B, rear jacket). The dominant classes include, very fine sand, coarse and medium silt (Fig. 4.7, Part C, rear jacket). These classes are predominantly subangular in appearance (Plate 4.5f). Sphericity ranges between values of .73 and .77 while roundness is .2 (Fig. 4.7, Part B, rear jacket). The grains have been subjected to some breakage and subsequent erosion. Solution diagenesis appears to be less pronounced than in preceding subdivisions. Silica precipitation is common. This subdivision is interpreted as alluvium deposited within a low energy environment, probably over bank.

Subdivision 3f(17.50m - 19.00m)

Sediments are very compact silts. Horizontal bedding planes are present in the lower sediments but are difficult to discern. An erosional contact (Disonformity A) is present between this subdivision and Unit 4 sediments. Ice wedge pseudomorphs intrude into Subdivision 3f. These casts are ca. 1m in width and 2m in depth. A soil horizon is present at Station 2 (Bombin op cit.)

Textural classification of this unit is silt. Samples analyzed from 18.00m and 18.50m have basically the same percentages (1%-82%-17%) and (0%-82%-18%), (Fig. 4.2). Classes are

predominantly subangular in appearance (Plate 4.6a) with sphericity values of .3 and .4 and roundness .5 - .6 (Fig. 4.7, Part B, rear jacket). No freshly broken grains were noted in material from this unit but some very eroded flake scars were present (Plate 4.6b). All grains have undergone considerable erosion. Solution diagenesis is very common. This subdivision is interpreted as a stable land surface of some duration which probably developed on a flood plain.

Station 13 Ice Wedge Pseudomorph

No textural analysis was completed on this sample. However the classes are subrounded to rounded in appearance (Plate 4.7a). Sphericity values range between .73 and .97 while roundness values range between .8 and .9 (Fig. 4.7, Part B, rear jacket). Many of the clasts are broken. Imbricated breakage is present (Plate 4.7 a & 7b). Some edge wear occurs, but in general, the edges retain a relatively fresh appearance. The morphology of these clasts are similar to Unit 4 sediments above 19.80m. Also a close similarity exists between the breakage patterns noted on the ice wedge example (Plate 4.7b) and the Unit 4 example (Plate 4.7f). Similarity of morphology and breakage patterning may indicate that Unit 4 sediments may have filled the ice wedge. Permafrost conditions are indicated by the presence of these ice wedge casts. probably during the existence Their Infilling indicates that a period of warming followed.

D. Unit 4(19.00m - 20.80m)

Sediments are homogeneous cross-bedded silts, sands and clays. Contact with Unit 5 is gradational. Fossils of wood, plants and fauna remains occur at the base of this unit. A Pleistocen megafauna (mammoth, horse and bison) is indicated by the fossil bone deposit. Organic detritus is present throughout.

Textural classification ranges from sandy silts to clayey silts with a mean texture of clayey silt (14%-65%-21%), (Fig. 4.3). Coarse and medium silts are the two dominant clasts throughout (Fig. 4.7, Part C, rear jacket). Very fine sand is significant to 20.00m then, very

Plate 4.6: Subdivision 3f and Unit 4 sediment grain characteristics

a. Subdivision 3f: General morphology.

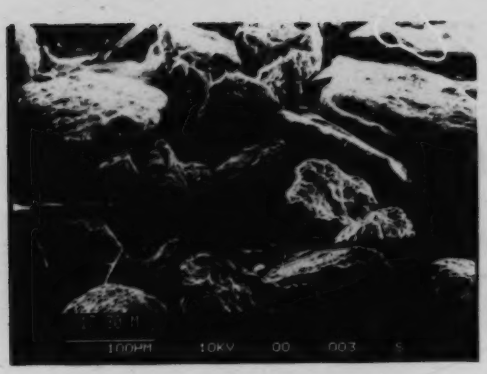
b. Subdivision 3f: Example of grain breakage with subsequent erosion.

c. Unit 4: General morphology.

d. Unit 4: Examples of solution diagenesis and silica precipitation.

e. Unit 4: Examples of subangular grains in the upper unit sediments.

f. Unit 4: Imbricated breakage pattern.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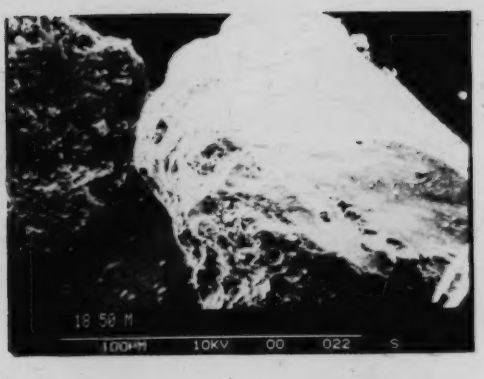
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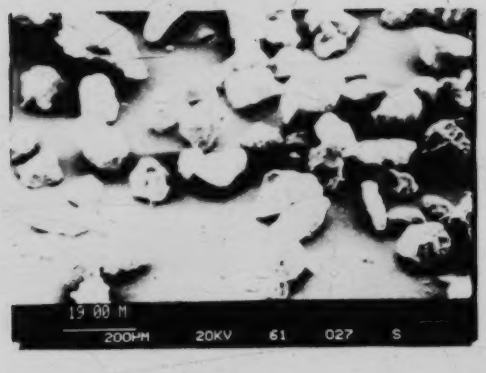
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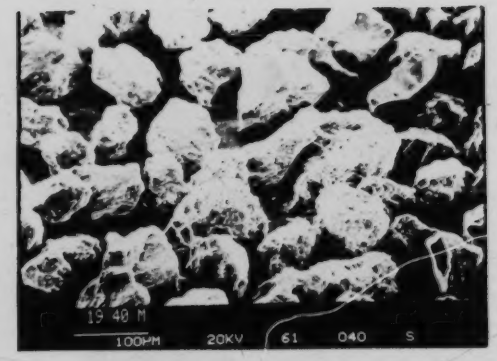

19 40 M
100MM 20KV 61 040 S

20 40 M
100MM 20KV 61 032 S

20 40 M

Plate 4.7: Units 4, 5, & 6 sediment grain characteristics

a. Unit 4: Exampls of grain characteristics from Stn. 13 ice cast.

b. Unit 4: Details of imbricated breakage on central grain in (a).

c. Unit 5: General morphology. pattern.

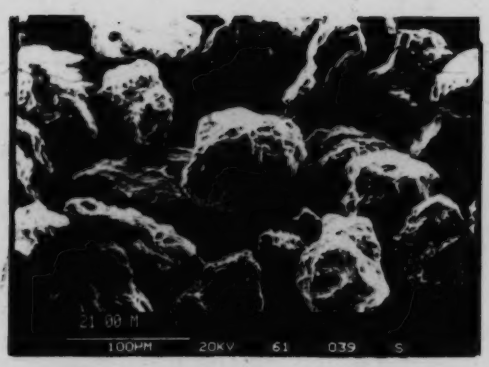
d. Unit 5: Conchoidal breakage

e. Unit 5: Detail of conchoidal breakage with

f. Unit 6: General morphology. subsequent erosion.

STN 13 2 ICE WEDGE CAST
100µM 10KV 00 018 S

ICE WEDGE CAST
40µM 10KV 00 019 S


21 00 M
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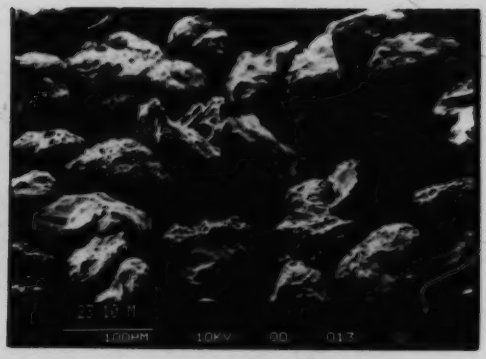
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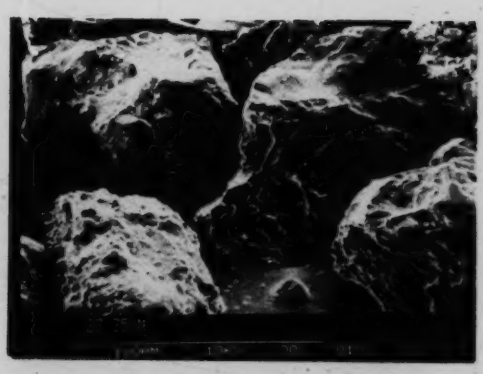


fine clay increases considerably.

The grains at the base of Unit 4 tend to be subangular to subrounded (Plate 4.6c). Sphericity values range between .83 and .85 and roundness values range between .5 and .6 (Fig. 4.7, Part B, rear jacket). All grains are eroded and exhibit solution diagenesis and silica precipitation (Plate 4.6d). No fresh or moderately eroded conchoidal or other breakage patterns are present below 19.80m. Above 19.80m the grains become more subangular in appearance (Plate 4.6e). Sphericity values group into two categories, namely .73 and .77 whereas roundness values range between .2 and .3 (Fig. 4.7, Part B, rear jacket). Solution diagenesis and silica precipitation are present. Imbricate fracturing is present on some grains (Plate 4.6f). This unit is interpreted as fluvial and that the sediments were deposited within a low energy environment.

E. Unit 5(>20.80m - 23.40m)

Sedimentation is similar but significantly finer than Unit 4. The cross-bedded sediments are highly disturbed at some stations. Large ice wedge pseudomorphs are present along the contact with Unit 4. The larger of these casts (Station 3) measures ca. 3m in width and 4m in depth. This cast dissects Unit 4 completely and tails out in Unit 3. Contact with Unit 6 is gradational.

Textural classification ranges from clayey silt, silt, to silty clay with a mean texture of clayey silt (4%-71%-25%), (Fig. 4.4). Sand clasts drop from 14% to 4% (Fig. 4.7, Part C, rear jacket). Medium and coarse silts and fine clays predominate. Very fine and fine sands are insignificant. The general morphology of the clasts are noted in Plate 4.7c. The clasts tend to be subangular to subrounded in appearance. Solution diagenesis and silica precipitation are common. Sphericity values range between .73 and .83 and roundness values range between .4 and .5 (Fig. 4.7, Part B, rear jacket). Many of the grains are broken. The breakage is both fresh (Plate 4.7d) and eroded (Plate 4.7e). This unit is interpreted as a stable land surface of some duration which probably developed on a flood plain.

F. Unit 6(>23.40m - 27.00m, Main Facet)

Sediments are horizontally bedded varved clays. Unit is non-polliferous.

Textural classification ranges from clayey silt, silty clay to clay with a mean texture of silty clay (2%-48%-50%), (Fig. 4.5). Unit 6 contains the highest clay fraction of the entire section (Fig. 4.7, Part C, rear jacket), while the sand content is insignificant. Fine clays reach their maximum value at 25.00m. Above this elevation, coarse and medium silt increase significantly. The general grain morphology is noted in Plate 4.7f. As noted, the grains tend to be subangular to blocky in nature. Sphericity values range between .73 and .85 and roundness values range between .4 and .6 (Fig. 4.7, Part B, rear jacket). 'Fresh' blocky fracture scars are present (Plate 6.8a). Conchoidal fractures are present but they are extremely eroded (Plate 6.8b). This unit is interpreted as glacio-lacustrine.

G. Significance of Conchoidally Fractured Lithics

Conchoidally fractured microflakes are recorded from sediments in stratigraphic context below till of late Wisconsinan age at the Hungry Creek site, northern Yukon, G.S.C. designation HH72-54 (Hughes et al. 1981). This site is located in the Bonnet Plume basin at 65° 34.5'N; 135° 30'W. Size of these microflakes are ±1mm. They were concentrated in fine grain sediments interpreted to have been deposited within a low energy fluvial environment. Sediments containing gravel as well as similarly textured sediments did not contain any microflakes. The microflakes are fresh in appearance and lack subsequent erosional features along their edges. Furthermore no possible parent lithics source, i.e., 'microcores' were recorded. Because no natural agency could be found to account for the microflakes, either through literature review or on site, it was argued that based on the critera presented in Fladmark (1982) they could be microdebitage from a nearby archaeological site or sites.

Conchoidally fractured lithics were also found at a second locality to the northwest on the Eagle River, G.S.C. designation HH80-12 (Hughes et al. 1981:357). Concentrations of these microflakes were far greater than at the Hungry Creek site and were abundant throughout

Plate 4.8: Unit 6 grain morphology and comparison between chert and coal fragments.

a. Unit 6: Example of grain breakage.

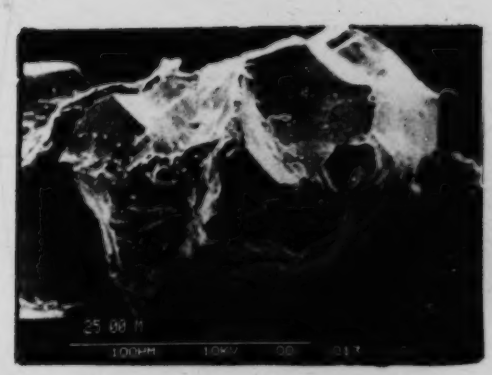
b. Unit 6: Conchoidally broken grain with subsequent erosion.

c. Conchoidally fractured black chert grain.

d. X-ray diffraction signature of (c).

e. Conchoidally fractured coal fragment.

f. X-ray diffraction signature of (e).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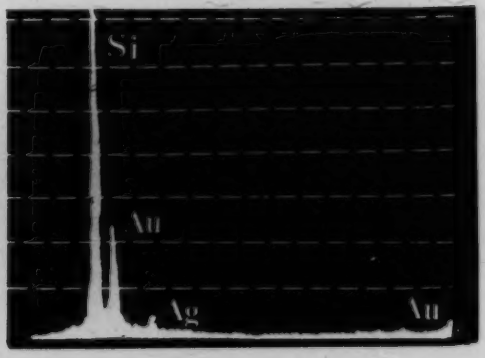
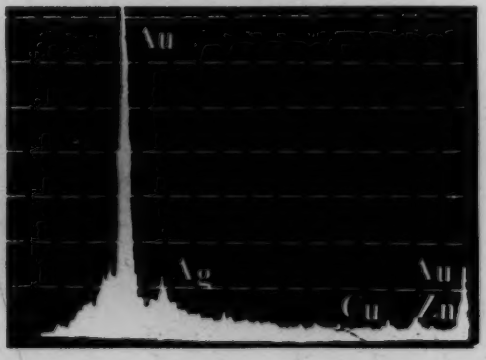
100UM
10KV


Si
Au
Ag
Au


Au
Ag
Au
Cu
Au

at least 4m of sediment. Because of the amount of microflakes at the HH80-12 site an archeological explanation seemed inappropriate. Consequently, it was suggested that a natural agency may have to be identified in order to account for their presence (Hughes et al. 1981:357).

Recognition of Microdebitage

According to Fladmark (1982:208-209) the criteria for recognizing archaeologically derived microdebitage include:

1. High angular forms, i.e., very low indices of rounding.

2. Transparent to translucent under transmitted light.

3. Often larger than mean particle size in any screened sample due to the thinness and elongation of the flakes which allows them to slip through the mesh of the screen.

4. Usually regular geometric shape, e.g., sub-rectangular, sub-triangular, trapezoidal and semi-lunate.

5. Usually some aspect of conchoidal fracture, e.g., positive and negative bulbs, multiple flake scars and concentric ripples.

6. Often lies close to the surface of the microscopic slide; best observed in the 0.5mm - 0.25mm size range due to their being below the mean focal plane of the matrix.

Large numbers of microfakes are produced below the 1mm size range during the making of an artifact. Fladmark(1982) notes that hard hammer percussion reduction of one obsidian cobble will produce ±400,000 particles in the 0.125 - 0.063mm size range and an estimated 1.0 - 1.1 k^{6} particles <0.063mm. Similar numbers are estimated for soft hammer and pressure flaking techniques. Homogeneous and heterogeneous silicates are the preferred lithic material for artifact production due to their fracturing characteristics, i.e., conchoidal fracturing. These silicates, especially quartz and quartzites are common constituents within fine

sands and silt clasts. Consequently, whenever any of these clasts are subjected to sufficient forces within an appropriate environment, microflakes will likely be produced.

Conchoidally fractured clasts are reported from glacial sediments and other high energy environments, e.g., surfs (Krinsley and Doonkamp 1973). Brown (1973:396) also reports freshly weathered conchoidally fractured grains from local bedrock sources which are indistinguishable from those from glacially derived sediments.

Locality 15 Microflakes

Locality 15 microflakes exhibit characteristics noted in Fladmark (1982) and those illustrated in Hughes et al.(1981). These include conchoidal breakage, high angular forms, regular geometric shape, positive and negative bulbs, multiple flake scars and concentric ripples. Additional breakage patterns include imbricated (Plates 4.5d; 4.6f and 4.7a & b) and high angled blocky (Plate 4.8). The Locality 15 specimens also differ from the Hungry Creek microflakes in that: a) examples of subsequent flake removal ca. .04mm in diameter from larger flakes ca. ±1mm (Plates 4.4b & e; 4.5e; 4.6b), b) examples of well-rounded single grains with flake scars are present (Plate 4.4d & f; 4.8a), and c) examples are present of varying degrees of rounding (edge erosion) Plates 4.1d; 4.2e; 4.4f; 4.5e and 4.8b).

Microflakes most similar to Fladmark's (1982) criteria for microdebitage are concentrated in Unit 2 sediments which are interpreted as glacio-lacustrine, as well as in the lower portion of Unit 3. The microflakes in the Unit 3 sediments are from foreset beds containing the coarsest sands in the section. Some mixing of sediments are likely between the two units. It may be significant that the Locality 15 microflakes and other broken grains are associated with sediments interpreted as being deposited during cold climatic conditions (Unit 2, Stn 13 ice wedge pseudomorph; and Unit 6), relatively high energy environment (Subdivision 3a) and/or non-polleniferous samples (Unit 2, Subdivision 3a, 3c, 3d, 3f and Unit 6).

A nearby archaeological site might be present. However, without the presence of macrodebitage (i.e., macroflakes greater than 1mm in size), it is tenuous to infer the presence

of an archaeological site from microflakes alone. Also, this concentration of microflakes is ca. 16m below the deposit of Old Crow tephra (85,000 - 115,000 B.P.; Schweger & Matthews n.d.) in sediments interpreted as Illinoian and early Sangamon in age (Morlan 1980, Hughes 1976). The hypothesis that the microflakes are microdebitage from an archaeological site seems unwarranted due to the age of the Unit 2 sediments, the fact that they are reworked glacio-lacustine sediments and the lack of macrodebitage.

It is more probable that they are the result of natural causes. To account for the presence of microflakes at the Locality 15 site, three hypotheses are presented below:

1. They could be derived from glacial sediments from the nearby Richardson Mountains. Distance does not seem to be a problem with this hypothesis as there is strong evidence that Early Carboniferous spores[5] were fluvial transported in suspension from Eagle Plains into the Old Crow Basin and deposited in Unit 4, 5 and 6 sediments. The size and densities of these spore and microflakes within the silt clasts are comparable. Therefore, the possibility exists that microflakes produced by glacial activity within the Richardson Mountains could have been transported into the Old Crow Basin as suspension load. If the microflakes remained in a continuous suspension load little or no subsequent erosion is likely. A study of Unit 1 sediments for microflakes would add more weight to this hypothesis. However, if microflakes are subjected to erosion during susspension transport then low indices of rounding may indicate local origins. Therefore:

2. The microflakes could have been produced by scouring of channel beds (or bedrock) by ice during spring break-up. In this case, they could not have moved very far in a fluvial system after production.

3. The microflakes could have been produced by sediment movement within permafrost.

Further research is recommended to test these hypotheses.

Conchoidally Fractured Semi-Translucent Black Microflakes

A sample of black semi-translucent microflakes between 2mm and 4mm were studied in order to evaluate the possiblility of coal fragments being misinterpreted as chert. Of the twenty

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[5]The significance of these spores in the Locality 15 sediments is discussed in Chapter 7.

five specimens studied, only one was found to be coal (Plate 4.8e). This specimen has similar visual characteristics to lithic microflakes (Plate 4.8c) indicating that care should be taken in identifying semi-translucent black specimens.

V. Fossil Pollen Results

A. Introduction

The fossil pollen record is presented as a relative percent pollen diagram in Figure 5.1 (rear jacket). The pollen counts for each sample are noted in the first column of this diagram. The number of slides required to reach this sum is expressed in microlitre (μl) volume, i.e., 1 slide contains 25 μl of silicone oil (each processed sample being suspended in 300 μl of silcone oil). The counts are therefore expressed as 'number of grains/ μl volume' required to reach sum.

A number of arboreal pollen (AP) types were found in low frequencies throughout the section. These include *Pinus, Corylus, Ostrya/Carpinus, Carya, Tilia, Ulmus* and *Juglans* type. Of these, only *Pinus* is still present in some parts of Alaska and the Yukon but not in the Old Crow Basin (Hulten 1968). Except for *Corylus*, which presently ranges into northern Alberta (Moss 1982), all the other taxa are native to eastern Canada (Hosie 1969). High frequencies of these pollen types are recorded in Tertiary deposits within the Old Crow Basin (J. Hopkin, Jr., pers. com., Institute for Sedimentary and Petroleum Geology, G.S.C., Calgary,1982). Consequently, it is probable that their presences in the Locality 15 sediments are the results of fluvial redeposition of pollen bearing Tertiary material. There is also the possibility that some Tertiary NAP pollen types of Quaternary taxa, may be represented in pollen assemblage as well. But due to the very low frequencies of the AP types it can be assumed, that if they are present, they only constitute a very low frequency of the total pollen and therefore should not skew the composition of the Quaternary pollen. For the purposes of describing the pollen diagram, the AP types noted above are considered as 'non-extant' arboreal pollen, i.e., not presently growing in the Yukon except for *Pinus*. Pollen frequency results from each unit are noted below.

B. Locality 15 Fossil Pollen

From datum to 3.35m the samples were not polleniferous. This includes Unit 2 and Subdivision 3a sediments. The remaining units, except Subdivision 3f, contained varying amounts of pollen as described below.

Subdivision 3b(3.35m - 7.45m)

The samples from this subdivision were not very polleniferous as only three of the six samples contained 2ollen. Pollen concentrations are low in the lower two samples as 3 and 4 slides were required to reach sums of 241 and 386 grains. The sample at 6.50m was richer yeilding a sum of 410 grains from 1 slide count.

Arboreal pollen (AP) dominates with high values ranging between 76% - 88%. This is composed largely of *Picea* with values up to 82% in the lower portion of the unit, decreasing to 34% higher in the unit. *Betula*, in turn, increases from 6% to 34%. *Alnus* ranges in value from 1% - 11%. *Myrica* and *Shepherdia canadensis* are inconsistently present. Non-extant pollen types include *Pinus*, *Ostrya/Carpinus*, *Corylus*, *Tilia*, *Juglans* type and *Ulmus* occur at less than 1% each.

Non Arboreal Pollen (NAP) show an increase in value towards the top of this unit. Ericaceae is the most common NAP type present with values of 7% - 14%. Grass, Cyperaceae and *Artemisia* are minor constituents having values of less than 5%. Thirteen additional NAP types are inconsistently present with values of 1% or less. Aquatic and Semi-Aquatics (A/SA) are present with values of 1% or less, these include *M. spicatum*, *Nuphar*, and *Potamogeton/Triglochin* type. *Sphagnum* spores are extremely common in all samples (28% - 42%). *Botryococcus* colonies are also very common in some samples (2% - 17%) while *Pediastrum* colonies are present only at 6.00m (<1%).

Pre-Quaternary spores are fairly common. The dominant type was identified as *Costatoperforosporites faveolitatus* Deak, 1962, (c.f. Singh 1971:81). This spore type is common in Early Cretaceous deposits in Western Canada (Singh pers. com. 1983).

Subdivision 3c(7.45m - 10.00m)

The sediments in this subdivision were predominantly polleniferous as five of six samples contained pollen but concentrations remained low. In samples from 7.45m and 8.00m, 5 and 4 slides were required to reach sums of 343 and 285 grains. Pollen was more prevalent in the upper portion of the subdivision where 1 to 2 slides were required to reach sums ranging between 409 to 7361 grains.

AP remains high, between 54% and 75%. *Betula* (25% - 39%) and *Picea* (27% - 38%) are the two co-dominant types. *Picea* is more common in the lower sediments while the upper sediments contained mostly *Betula*. *Alnus* continues to be the third major AP component with values of 5% - 9%. *Salix* is inconsistently present with values of <1%. *Myrica* continues to be present to 8.00m. Five AP taxa with percentages of less than 1% include *Pinus*, *Carya*, *Tilia* and *Juglans*. Of these, *Pinus* is the most abundant.

NAP continues to increase in frequency through this subdivision reaching 46% at 9.00m. Above 9.00m, NAP decreases to 25% - 26%. Ericaceae reaches a maximum value of 20% at 8.00m then declines to 3% - 10%. Grass remains fairly constant at 4% - 6% over this unit zone. Cyperaceae exhibits a major increase at 8.90m with a value of 29% but then it drops to 6% - 7%. *Artemisia* is consistently present throughout this unit with values of 1% - 2%. Fifteen additional NAP types are represented within this subdivision with low values of 1% or less. *Potamogeton/Triglochin* type is the more common A/SA taxon present. At 7.45m *Sphagnum* reaches its highest value (52%) for the entire section. Above this elevation *Sphagnum* rapidly decreases in value and by 9.50m, drops to 6%. *Botryococcus* colonies are abundant to 8.00m, maintaining values of between 43% - 53%. In contrast, *Pediastrum* colonies, where present, do not exceed 2%.

PreQuaternay spores remain relatively common reaching 6% at 7.45m but then drop to 2% at 9.50m. The early Cretaceous spore noted is the most dominant pre-Quaternary type.

Subdivision 3d(10.00m - 16.00m)

Ten of 12 samples contained pollen. Pollen concentrations are generally higher then the preceding subdivision. One or 2 slides were required to reach sums ranging between 414 - 3714 grains.

AP ranges between 53% - 76% below 15.00m then drops to its lowest value (45%) in Unit 3 at 15.50m. *Betula* replaces *Picea* in dominance AP with values of 25% - 41%. Above 13.00m, *Picea* drops significantly in value (15% - 5%). *Alnus* remains consistent throughout at slightly higher frequencies than in the preceding subdivision. At 10.50m *Alnus* reaches 21%, its highest value for the entire section. The remaining values for this species fluctuate between 5% - 12%. *Salix* values are constant but with values not exceeding 1%. *Myrica* is again present above 13.00m. A few grains of *Shepherdia canadensis*, *Elaegnus*, and *Cornus stolonifera* are present in a number of samples. Seven non-extant AP types are present in most samples. *Pinus* becomes less common and shows up in only three samples, while *Carya* is the most frequent type present.

Above 12.50m, NAP values increase significantly from 24% to 46% at 14.00m. After undergoing a slight decrease between 14.50m and 15.00m it reaches a value of 52% at 15.50m. This is the first occurrence wherein NAP values are greater than AP. Ericaceae pollen peaks at 12% at 10.00m, drops to 4% - 6% until 14.00m, after which, it rises to its maximum section value of 24% at 15.50m

Grass and Cyperaceae exhibit similar frequencies peaking at 14.00m; 17% for grass and 15% for Cyperaceae. Caryophyllaceae and Tubuliflorae high spine(HS) type now become consistent minor components within the sediments. *Artemisia*, Chenopodiaceae/*Amaranthus(Am)*, Tubuliflorae low spine (LS), Leguminosae, *Epilobium*, *Phlox*, *Polemonum* and *P. bistorta* type are also abundant but at lower frequencies (1% or less). Twenty additional NAP types are inconsistently present within this unit. Above 12.50m, increases in NAP species numbers are significant. This is of interest as the sediments are also more polleniferous above this level (12.50 - 15.00m) as pollen sums were obtained from one

slide count compared to the two slides required for the underlying samples of this subdivision.

Below 11.00m, *Sphagnum* maintains a consistent value of between 12 and 13%. Between this elevation and 15.00m it achieves lows of 3% - 5%, but above 15.00m, it again registers a higher value range of between 19% - 28%.

Dryopteris is consistent throughout and achieves a maximum of 3% at 15.50m. *Botrychium* is present above 12.50m in all samples. *Botryococcus* colonies increase significantly above 14.00m reaching a maximum of 28% at 15.50m. Pre-Quaternary spores drop in frequency but still remain in all samples. Again an early Cretaceous provenience is indicated by the spore type.

Unit 3e(16.00m - 17.50m)

Five of the 6 samples were polleniferous. Four of these samples were rich in pollen as only one slide was required to reach sums from 439 to 2170 grains. One sample from sand at 16.76m required a count of 4 slides to obtain a sum of 153 grains.

AP dominates reaching a maximum value of 71% at 16.80m. Above this elevation AP frequencies drop. *Picea* ranges from 4% - 51% while *Betula* ranges between 4% - 63%. *Alnus* remains consistent at 4% - 12%. *Salix* and *Myrica* are present but with low frequencies of 2% or less. The number of non-extant AP types declines in both numbers and frequency.

NAP frequencies drop throughout this subdivision until 16.80m where the trend is reversed. Ericaceae, grass and Cyperaceae have comparable values, 4% - 16%, 5% - 8%, and 6% - 13% respectively. Tubuliflorae HS, *Artemisia* and Caryophyllaceae continue as minor components. Cruciferae, *Polemonium*, *P. bistorta* are also fairly common but at slightly lower frequencies. Seventeen additional NAP taxa are represented in these sediments at low values of 1%.

Sphagnum decreases slightly from that noted in the preceding unit but still maintains a modest range of 7% - 13%. *Equisetum* is also fairly consistent with less than 1% values. *Botryococcus* colonies are still present in these sediments with values of 5% - 14% while

Pediastrum now become more common (<1% - 4%). Pre-Quaternary spores are insignificant.

Subdivision 3f(>17.50m - 19.00m)

Two samples were processed from these silts and both were non-pollen bearing.

C. Unit 4(19.00m - 20.80m)

All eight samples processed from this unit were polleniferous. Four of the samples were from the base of Unit 4, i.e., at 19.00m along the erosional contact (Disconformity A) at Stations 2, 14, 3 and 12 (Fig. 5.1, rear jacket). These samples contained pollen concentration of between 303 to 2170 grains. Pollen data from the 4 stations along the 19.00m erosional contact are presented first under the heading 'Disconformity A Samples' and the remaining portion of the unit, are discussed under the heading 'Upper Unit 4 Samples'.

Disconformity A Samples

All four of these samples were dominated by NAP taxa with fairly high values of 55% - 98%. The Station 2 sample is dominated by Cyperaceae (76%). Grass is low in comparison (6%) while *Artemisia* has a value of 4%, followed by Ericaceae (1%). *Picea* is common (10%) while *Betula* is less so with a value of 4%. *Sphagnum* is present with a value of 3%. *Pediastrum* colonies increase substantially to 12%.

Grass dominates the Station 14 sample with a frequency of 70% followed by Cyperaceae (11%), Caryophyllaceae (10%), *Artemisia* (4%), Cruciferae and *Phlox* both with 1%. Tubuliflorae HS, LS and Liguliflorae all combine for a frequency of 1%, Ericaceae, *Plantago* sp, *P. amphibium/persicaria* type, Umbelliferae undifferentiated and *Valeriana* also combine for a frequency of 1%. AP species, e.g. *Picea*, *Betula*, *Alnus*, and *Salix* when combined only achieve a <1% frequency. *Sphagnum* and *Dryopteris* spores are present in low numbers while pre-Quaternary spores and *Pediastrum* colonies are absent.

Cyperaceae is the most common pollen type in the Station 12 sample with a frequency of 23%. It is closely followed by *Picea* (20%), *Betula* (17%), grass (11%) and Chenopodiaceae/*Am.*(7%). Minor constituents of this assemblage include *Alnus* (3%), *Artemisia* (3%), Tubuliflorse HS (3%) and Ericaceae and Caryophyllaceae both with 2% each. A frequency of 1% is achieved by *Salix*, *Polemonium*, *P. bistorta*, and *Mentha* type. Non-extant AP species represented in this sample (<1%) include *Corylus* and *Ostrya/Carpinus*. *Pediastrum* colonies are very common (78%). Pre-Quaternary spore remain absent.

Cyperaceae also dominates the Station 3 sample with a 42% frequency. Again *Picea* follows with 18%. Grass pollen (14%) and *Betula* (10%) are also common components of this assemblage. Minor constituents include Chenopodiaceae/*Am* (3%), *Alnus* (2%), Ericaceae (2%), Caryophyllaceae (2%), Tubuliflorae LS (2%), Tubuliflorae HS (1%) and Cruciferae (1%). *Sphagnum* is also present with a 2% frequency. *Pediastrum* colonies remain significant at 56%. A few grains of *Pinus*, *Carya*, and *Tilia* were noted. Pre-Quaternary spores are absent. It is of special interest to note that none of the Disconformity A samples contained any pre-Quaternary spores.

Upper Unit 4 Samples

Above 19.00m the AP frequency replaces NAP as the dominant class. The AP frequency increases to a value of 75% at 19.40m, drops to 50% by 19.80m then remains at 52% to 20.80m. *Picea* is the most common AP type with a frequency range of 56% - 21%. It is followed by *Betula* (13 - 22%), and *Alnus* (2% - 4%). *Salix*, *Myrica* and *Shepherdia canadensis* are present in some samples only. Occurrences of non-extant species e.g. *Pinus*, *Carya*, *Corlyus* and *Tilia* were noted.

Above the disconformity, the NAP drops to 25%, but increases again, maintaining comparable values with that of AP above 19.80m. Cyperaceae continues to be the most common NAP type present in this unit with values ranging between 3% - 19%. *Artemisia*

increases to 12% at 20.70m. Grass (1-8%), Ericaceae (3-7%), Tubuliflorae HS (1-5%) Caryophyllaceae (1-2%) and Chenopodiaceae/*Am.*(1-2%) combine to form a fairly important part of the NAP assemblage.

Other minor constituents include Tubuliflorae LS, Liguliflorae, *Cardimine*, *Polemonium*, *Plantago*, *P. bistorta* type and *Valeriana*. *Saussurea* type is of interest as it achieves a frequency of 5% at 19.80m. Twenty additional NAP types are recorded in this samples thus making Unit 4 sediments unique in that it contains the highest number of NAP species for the entire section (Fig. 5.1). *Typha* pollen appears for the first time in this unit and was found in all samples. *Potamogeton/Triglochin* is present throughout. *Sphagnum* with frequencies of 14% - 6% is also common. *Pediastrum* colonies peak at 20.40m with a frequency of 44%.

Pre-Quaternary spores reappear in this unit with a value range of 4% - 6%. These spores differ from those recorded from the underlying Unit 3 sediments. Where the spores from the lower sediments were Early Cretaceous in age the spores in the Unit 4 sediments are derived from still older, Carboniferous, deposits and have been identified as Viséan in age and resemble components of the Aurita assemblage of Playford (1962), (Utting pers. com., 1983). A list of the identified spores are noted on Table 5.1. The presence of these spores above Disconformity A have possible paleofluvial implications. Their significance will be discussed in Chapter 7.

D. Unit 5(20.80m - 23.40m)

All five samples processed from this unit were polleniferous but pollen concentrations were lower then the underlying Unit 4 samples. From 2 to 5 slides were required to reach sums that ranged from 139 - 746 grains. Generally the lower samples contained the most pollen.

The unit is dominated by AP species to 22.70m with values ranging between 59% - 65%. *Picea* predominates with 26% - 59% frequencies, followed by *Betula* (4-27%) and *Alnus*(1-5%). *Betula* is common in the lower portions of this unit reaching its maximum at 21.80m, but then,

Table 5.1: List of Early Carboniferous spores from Units 4, 5 & 6 Sediments

Cirratriradites elegans (Waltz) Pontonie and Kremp
Densosporites anulatus (Loose) Smith and Butterworth
Densosporites duplicatus (Naumova) Pontonie and Kremp
Densosporites rarispinosus Playford
Densosporites spitsbergensis Playford
Densosporites subcrenatus (Waltz) Potonie and Kremp
Diatomozonotriletes saetosus (Hacquebard and Barss) Hughes and Playford
Discernisporites micromanifestus (Hacquebard) Sabry and Neves
Knoxisporites sp.
Lycospora pusilla (Ibrahim) Schopf, Wilson and Bentall
Microreticulatisporites lunatus Knox
Murospora aurita (Waltz) Playford
Murospora friendii Playford
Potoniespores delicatus Playford
Rotaspora fracta (Schemel) Smith and Butterworth
Stenozonotriletes clarus Ishchenko
Tripartites incisotrilobus (Naumova) Karczewska and Turnau
Vallatisporites sp.

between 22.20m and 22.70m, its frequency drops to less than 5%. *Picea* peaks at two elevations, 21.20m and 22.70m. Above 22.70m *Picea* again drops in value. *Alnus* pollen in this unit has a higher frequency then it achieved in the preceding Unit 4. Non-extant AP species are inconsistently present in some samples. *Pinus* is of interest as it exhibits a 2% frequency at 23.40m. This is the highest value *Pinus* obtains in the Locality 15 sediments.

NAP taxa values range between 34% - 40% below 22.70m but then increases to 62% at 23.30m. Cyperaceae is significant in the upper part of Unit 5 reaching 27% at 23.30m while *Artemisia* is the predominant type in the lower portion of this unit. *Artemisia* reaches a value of 15% at 21.70m but then drops to 2% at 22.70m and 23.30m. Grass pollen fluctuates with values of between 1% - 9%, exhibiting three peaks, one of which coincides with an *Artemisia* peak at 21.70m. A second peak of 7% occurs with Cyperaceae at 23.30m. Ericaceae is less common in these sediments, only reaching values of 2% - 5%. Chenopodiaceae/*Am.*, Tubuliflorae HS and LS, Liguliflorae Caryphyllaceae and *Valeriana* are common as minor constituents throughout. *Cardimine* type is significant at 22.70m reaching 6%. *Phlox* and *Polemonium* are present in the upper sediments with values of 1%. Seven additional NAP taxa occur in various samples. This is considerably less than that noted in the Unit 4 deposits. *Typha* pollen is present in the lower sediments but disappears above 22.70m. *Menyanthes* achieves a 1% frequency at 23.70m. The only other A/SA occurring in this unit is *M. Spicatum*,(< 1%) at 21.80m.

Pteridophyta taxa are fairly common with *Dryopteris* type being the most dominant, with values of 3% - 13%. *Sphagnum* remains a consistent taxa throughout with frequencies of between 7% - 14%. *Pediastrum* maintains values of 2% - 17%. Pre-Quaternary Viséan spores increase in frequency throughout Unit 5 reaching an extremely high value of 95% at 23.40m.

E. Unit 6 (23.40m - 27.00m

Only one of eight samples processed from this glacio-lacustrine unit contained pollen. This was from a clay sample at 25.00m. The pollen concentration was low, 5 slides were required to reach a sum of 192 grains. .

The taxa ratio between AP and NAP was 52% in favour of the AP taxa. Species represented were *Betula* (39%), *Picea*(8%) and *Alnus* (2%). Some non-extant species types were noted.

The three most common NAP taxa within this assemblage included Ericaceae, grass and Cyperaceae. All had a frequency of 7%. *Artemisia* was slightly less common (6%). Additional NAP taxa represented include, Chenopodiaceae/*Am.* (2%), Caryophyllaceae (2%), Liguliflorae (1%), Tubuliflorae HS (1%) and *P. amphibium/ persicaria* type (1%). Viséan spores were still present with a frequency of 21%.

VI. Taphonomic Analysis

Sixty-two samples were processed for pollen, 37 of which, were polleniferous. Sedimentological analysis of all the samples resulted in the following categories: clayey silt (n=19), sandy clay silt (n=11), sandy silt (n=7), fibrous organic (n=7), silty clay sand (n=4), silty clay (n=3), sandy silt clay (n=2), silt (n=2), sandy clay silt/sandy silt (n=2), sand (n=1), clay (n=1) and one silty sample (not analyzed). Six of the fibrous organic samples were interpreted as allochthonous peats. The one autochthonous sample was from Unit 5, Station 9 at 22.20m. Polleniferous samples are listed on Table 6.1. The 25 sterile samples are noted on Table 6.2.

Pollen concentrations generally tend to increase with elevation in Locality 15 sediments, but these values vary within and between unit designations. Concentrations of high values are present in the following units: a) Subdivision 3d: 13.50m to 14.50m (44,568 and 14,973 pollen grains/300μl/50g of sediment); b) Subdivision 3e: 16.81 to 17.00m (26,040 and 11,604 grains/300μl/50g of sediment); c) Unit 4: 19.00m to 19.40m (7,272 to 395,472 grains/300μl/50g of sediment). Six samples containing very low concentrations, i.e., below 1,000 grains, are present at various elevations: in Subdivision 3b (4.50m and 7.45m), 3c (8.00m), 3e (16.76m), Unit 5 (23.40m) and Unit 6 (25.00m). The Unit 5 sample has the lowest value for the entire section: 334 pollen grains/300μl/50g of sediment. Poorly preserved pollen concentrations are noted in samples from Subdivisions 3c, 3d and 3e. These concentrations are within samples with high pollen sums. Well-preserved pollen is present in Subdivision 3b, Units 4 and 5. Pollen preservation and indices are discussed in greater detail below. AP values remain high through Unit 3 subdivisions but some samples in 3d and 3e contain higher frequencies of NAP. In the lower portion of Unit 4, NAP values predominate. In the upper part of Unit 4 and in Unit 5, AP values again have higher frequencies then NAP but the upper most sample in Unit 5 just below Unit 6 has a higher NAP value.

Table 6.1: Data Comparison of Polleniferous Samples to Sediment Type

Unit	El.>H2O	Sediment Type: %Sand-%Silt(cs-ms-fs-vfs)-%Clay	Pol.Con./300µl/50g
6	25.00m	clay: 0%-14%(0-2-4-8)-86%	461
5	23.40m	clayey silt: 2%-77%(16-34-18-9)-21%	334
5	22.70m	clayey silt: 2%-67%(20-26-18-3)-31%	2,088
5	22.20m	fibrous organic	4,740
5	21.80m	clayey silt: 8%-79%(20-32-14-13)-13%	1,668
5	21.20m	clayey silt: 7%-65%(19-30-9-7)-28%	2,142
4	20.80m	clayey silt: 5%-70%(23-28-12-7)-25%	4,476
4	20.20m	clayey silt: 14%-69%(17-33-11-8)-17%	9,576
4	19.80m	sandy silt: 28%-60%(20-22-10-8)-12%	4,068
4	19.40m	clayey silt: 8%-60%(16-23-13-8)-32%	13,656
4(Stn 20	19.00m	fibrous organic	7,272
4(Stn 3)	19.00m	fibrous organic	34,521
4(Stn 14)	19.00m	fibrous organic	395,472
Stn 12	19.00m	silty(not analyzed)	3,600
3e	17.00m	sandy clay silt: 31%-50%(14-15-12-9)-19%	11,604
3e	16.81m	clayey silt: 12%-62%(18-19-11-14)-26%	26,040
3e	16.76m	sand: 84%-10%(8-0-1-1)-6%	459
3e	16.50m	clayey silt: 8%-70%(25-22-12-11)-22%	5,268
3e	16.00m	sandy clay silt: 16%-59%(28-17-7-7)-25%	8,472
3d	15.50m	clayey silt: 8%-66%(22-19-12-13)-26%	2,484
3d	15.00m	clayey silt: 2%-79%(13-32-19-15)-19%	6,288
3d	14.50m	clayey silt: 7%-66%(14-22-16-14)-27%	14,976
3d	14.00m	sandy clay silt: 29%-48%(10-18-11-9)-23%	23,280
3d	13.50m	clayey silt: 5%-64%(20-7-22-15)-31%	44,568
3d	13.00m	sandy clay silt: 37%-41%(10-17-6-8)-22%	6,108
3d	12.60m	sandy clay silt: 17%-57%(26-16-7-8)-26%	7,296
3d	11.00m	sandy silt: 33%-61%(35-18-3-5)-6%	2,718
3d	10.50m	sandy silt: 37%-53%(22-17-8-6)-10%	3,234
3d	10.00m	sandy silt: 21%-71%(29-22-11-9)-8%	2,826
3c	09.50m	silty sand: 72%-22%(6-7-5-4)-6%	2,454
3c(Stn 10)	09.00m	fibrous organic	12,492
3c(Stn 9)	09.00m	fibrous organic	8,712
3c	08.00m	clayey silt: 7%-74%(21-23-19-11)-19%	856
3b	07.45m	s.c. silt/s. silt: 25%-60%(22-19-10-9)-15%	823
3b	06.50m	fibrous organic	4,920
3b	06.00m	sandy silt: 31%-62%(34-18-2-8)-7%	1,080
3b	04.50m	sandy silt: 27%-64%(10-14-14-26)-9%	964

Table 6.2: Textural Classification of Non-Polleniferous Samples

Unit	Elevation	Sediment Type	%Sand-%Silt(cs-ms-fs-vfs)-%Clay
6	25.60m	clayey silt	2%-53%(4-14-13-22)-45%
6	25.55m	clayey silt	7%-68%(37-20-5-6)-25%
6	25.30m	silty clay	2%-43%(6-18-11-8)-55%
6	24.40m	silty clay	1%-45%(5-12-11-17)-54%
6	23.60m	clayey silt	3%-56%(8-16-15-17)-41%
3f	18.50m	silt	0%-82%(7-49-18-8)-18%
3f	18.00m	silt	1%-82%(2-56-15-9)-17%
3e	17.50m	sandy clay silt	21%-57%(9-30-9-9)-22%
3e	17.30m	s-c silt/s silt	24%-61%(14-34-10-3)-15%
3d	12.30m	clayey silt	8%-74%(28-22-15-9)-18%
3d	12.00m	clayey silt	5%-63%(9-25-15-15)-32%
3c	8.50m	silty clay sand	40%-38%(13-9-7-9)-22%
3b	7.00m	sandy clay silt	25%-55%(19-18-10-8)-20%
3b	5.50m	sandy clay silt	31%-49%(18-13-10-8)-20%
3b	5.00m	silty clay sand	46%-33%(15-7-7-4)-21%
3b	3.67m	sandy silt	20%-69%(32-10-8-19)-11%
3b	3.55m	silty clay sand	47%-28%(10-4-6-8)-25% -7.6-9.4)-19.4%
3a	3.35m	sandy clay silt	16%-53%(17-15-14-7)-31%
3a	2.55m	sandy clay silt	16%-56%(19-14-14-9)-28%
3a	2.20m	sandy clay silt	28%-49%(15-15-9-10)-23%
3a	1.67m	silty clay sand	62%-21%(9-3-4-5)-17%
3a	1.40m	silty sand	77%-14%(8-3-4-5)-9%
2	1.15m	sandy silt clay	24%-37%(12-7-7-11)-39%
2	1.10m	sandy silt clay	26%-33%(10-8-5-10)-41%
2	0.00m	silty clay	3%-46%(13-11-8-14)-51%

Polleniferous Sediment Characteristics

Variable pollen concentrations are present within the different sediment categories. These are ranked on Table 6.3. The fibrous organic category was highly polleniferous with a concentration of 66,876 pollen grains. Both sandy clay silt (11,352 pollen grains) and clayey silt (9,601 pollen grains) are comparable to fibrous organics, if the highly polleniferous Station 14 sample is excluded. There is a substantial decrease between these values and the sandy silt (2,482 pollen grains) and silty sand (2,454 pollen grains). Low pollen concentration was also found within sandy clay silt/sandy silt (823 pollen grains) and the clay (461 pollen grains) and sand (459 pollen grains) fractions.

There appears to be a relationship between well and poorly preserved pollen within the sediment categories. Three discernable grouping are noted (Table 6.3). Sediments containing the highest frequencies of well preserved pollen include: fibrous allochthonous organics (63 %), clayey silt (60%), and sandy clay silt/sandy silt (65%). A second grouping includes: sandy clay silt (52%) and silty sand (58%). Sand (34%) and clay (22%) contain the least amount of well preserved pollen. It should be noted that there was only one sample each for silty sand, sandy clay silt/sandy silt, clay and sand. A number of the above noted categories contained samples which were sterile. These are listed in Table 6.4. Four additional sediment categories were completely non-polleniferous: silty clay sand, silt, sandy silt and silty clay.

Discussion and General Conclusions

Because of the complex nature of alluviation and lacustrine deposition it may be expected that some samples will likely be sterile or contain redeposited pollen grains. It is tempting to suggest that sediments containing little or no pollen were deposited during winter and early spring before pollen production and dispersal took place. This may explain the sterile nature of samples interbedded between polleniferous samples that were interpreted as being laid down within a low energy environment. A study of pollen concentrations within a suspension load of a meandering stream and correlation with a pollenation cycle would be necessary to

Table 6.3: Mean % Pollen Concentrations ranked according to Sediment Type

Sediment type	%Sand-%Silt(cs-ms-fs-vfs)-%Clay	Pollen con./300µl/50g
fibrous organic +Stn 14 (n=7)	n/a	66,876
fibrous organic -Stn 14 (n=6)	n/a	12,110
sandy clay silt (n=5)	26%-51%(17.6-16.6-8.6-8.2)-23%	11,352
clayey silt (n=14)	7%-69%(18.86-25-14.7-10.57)-24%	9,601
sandy silt (n=6)	29.5%-61.8%(25-18.5-8-10.33)-8.67%	2,482
silty sand (n=1)	72%-22%(6-7-5-4)-6%	2,454
sandy clay silt/sandy silt (n=1)	26%-60%(22-19-10-9)-15%	823
clay(n=1)	0%-14%(0-2-4-8)-86%	461
sand (n=1)	84%-10%(8-0-1-1)-6%	459

Table 6.4: Non-Polleniferous Sediment Means

Sediment Type	%Sand-%Silt(cs-ms-fs-vfs)-%Clay
sandy clay silt(n=6)	23%-53%(16-17.5-11-8.5)-24%
clayey silt (n=5)	4%-62%(15-18-14-15)-34%
sandy silt(n=1)	20%-69%(32-10-8-19)-11%
silty sand (n=1)	77%-14%-(8-3-4-5)-9%
sandy clay silt/sandy silt (n=1)	24%-61%(14-34-10-3)-15%
clay (n=0)	n/a
sand (n=0)	n/a
silty clay sand (n=4)	49%-30%(12-6-6-7)-21%
silt (n=2)	0.5%-82%(4.5-52.5-16.5-8.5)-17.5%
sandy silt clay (n=2)	25%-35%(11-7.5-6-10.5)-40%
silty clay (n=3)	2%-45%(8-14-10-13)-53%

address this problem. Likewise, rapid deposition of coarse sediment may also explain the lack of pollen in some samples. In addition, glacio-lacustrine samples may be expected to be predominantly non-polleniferous due to lower numbers of plant species in conjunction with alternative asexual propagation strategies, e.g., cloning. A similar situation may also exist during severe periglacial conditions as well (cf. Cwynar 1979).

The non-polleniferous nature of Units 2 and 6 is understandable as they are interpreted as glacio-lacustrine. In reference to Subdivision 3a it is interesting to note that they are coarse-grained, containing both foreset and horizontal bedding planes. Some mixing is likely with Unit 2 sediments. The foreset beds probably contain little or no suspension load material. Unit 2, Subdivisions 3a and 3b both contain similar frequencies of conchoidally fractured lithics, indicating the likelyhood of a common source. Also, these sediments may have been deposited during the terminal Illinoian glaciation.

Subdivision 3f, also non-polleniferous, is composed of massive silts with ice wedge pseudomorph intrusions. This subdivision was previously interpreted to represent a soil horizon developed on a floodplain location. The internal dynamics of this soil horizon and the periglacial conditions (promoting asexual propagation) may explain the sterile nature of this deposit.

The high frequencies of poorly preserved pollen between 13.50m and 17.00m may indicate extensive pollen redeposition over this interval (Table 6.1). Therefore, Subdivision 3d may be composed of reworked basin sediments for a period of some duration. Unit 6 clay contains the most poorly preserved pollen. Reworking of pollen is suggested although the AP and NAP ratio is somewhat comparable to that of Unit 5 samples. The sand sample at 16.76m contains a high frequency of poorly preserved pollen, which may reflect the coarse nature of the sample. It is of interest to note that some of the coarsest sediment categories e.g., sandy clay silt/sandy silt, also contain high frequencies of well-preserved pollen grains. This may be reflect the high values of sediment clasts within the suspension load range (Table 6.3).

A. Pollen Concentrations in Silt

Because pollen size ranges and specific gravities fall within that of silt sediment type it is generally accepted that pollen concentrations are more likely to be higher in silts than in other sediment types. The suggested settling velocities for 8 pollen and spore taxa are noted on Table 6.5. *Artemisia, Alnus*, Gramineae, Cyperaceae, and *Betula* may be expected to fall within the fine to very fine silt size range (.0039mm - .0156mm). *Picea*, Ericaceae and *Sphagnum* may be expected to fall within the coarse to medium silt size range (.0156 - .0625mm). *Artemisia* pollen was excluded from this analysis because of its insufficient concentrations. For testing purposes, coarse and medium silt percentages were combined as were fine and very fine silt percentages.

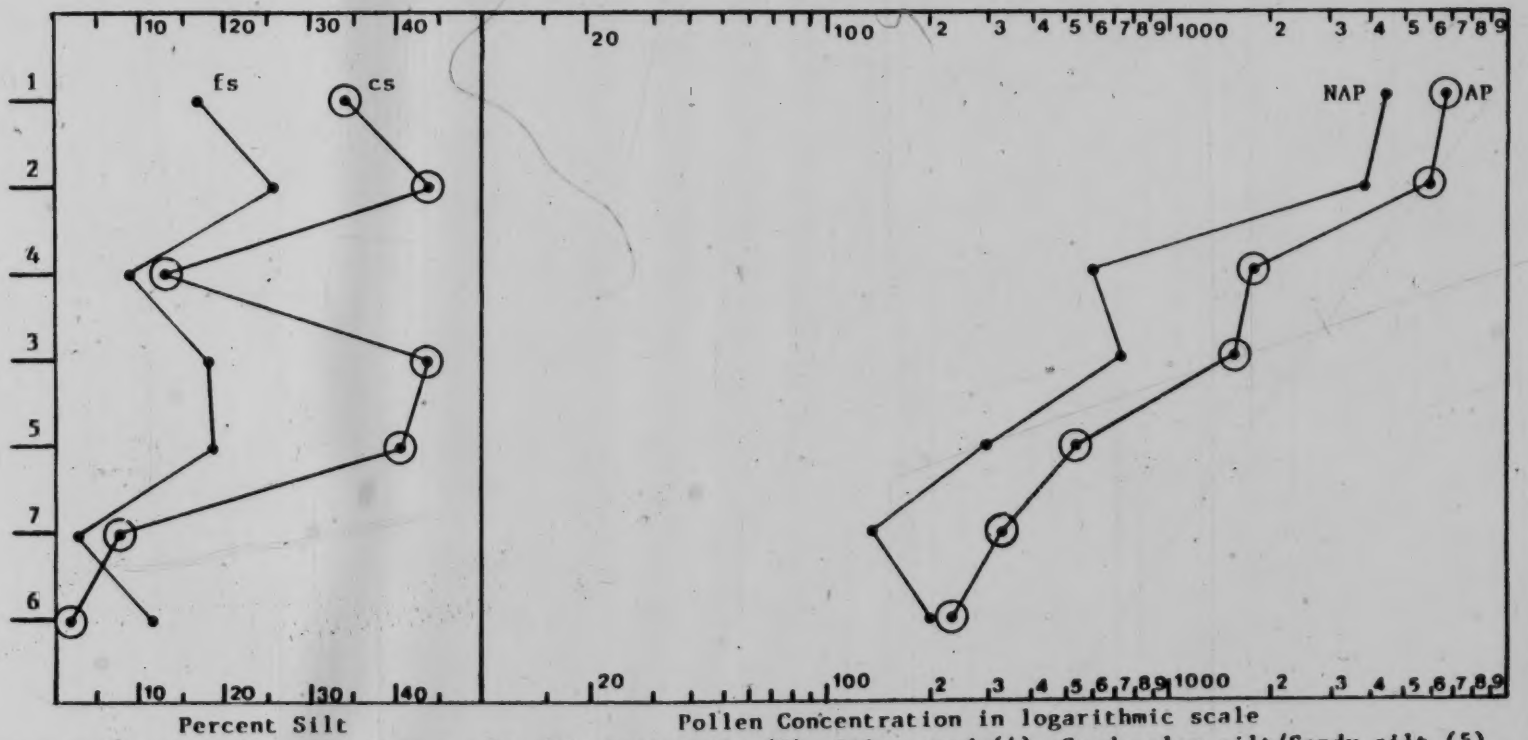
The relationship between pollen concentration and silt grain size distribution were determined in the following manner. Polleniferous sediment types from Table 6.3 were first ranked according to pollen concentration values from AP, NAP and 7 selected taxa in descending order. The percent coarse and/or fine silt contained within each of the sediment type was plotted as relative percentages while pollen concentration was plotted in logarithmic scale. The two resulting curves should parallel one another thus indicating a positive correlation if there is a relationship between pollen concentration for a given taxa and percent of coarse and/or fine silt for the polleniferous sediment types. These data led to eight hypotheses that are presented and tested here.

Hypothesis 1:

Arboreal pollen will become incorporated within the coarser silt fraction during fluvial transport and will likely fall out of suspension along with that fraction during sediment deposition. Therefore, AP pollen concentrations may be related to the amount of coarse silt within a sediment deposit. The opposite should hold true for NAP pollen concentrations and fine silt. These values are compared in Figure 6.1. A good correlation was obtained between increases in AP and coarse silt values, and with NAP and fine silt. Consequently, this hypothesis is accepted.

Table 6.5: Equivalent Settling Velocities For 8 Pollen and Spore Taxa

Picea	5.3 Phi	(Medium Silt)
Ericaceae	5.3 Phi	(Medium Silt)
Betula	6.1 Phi	(Fine Silt)
Alnus	7.5 Phi	(Very Fine Silt)
Gramineae	6.8 Phi	(Fine Silt)
Cyperaceae	6.5 Phi	(Fine Silt)
Artemisia	7.6 Phi	(Very Fine Silt)
Sphagnum	4.05 Phi	(Coarse Silt)



Code: Sandy silt clay (1), Clayey silt (2), Sandy silt (3), Silty sand (4), Sandy clay silt/Sandy silt (5) Clay (6), Sand (7); coarse silt (cs), fine silt (fs).

Figure 6.1: AP and NAP concentrations compared to coarse and fine silt fractions within sediment categories

Hypothesis 2:

Picea pollen should become incorporated into the coarser silt fraction of a suspension load during fluvial transport and should fall out of suspension along with that fraction during sediment deposition. Therefore, concentrations of *Picea* pollen may be related to the amount of coarse silt within a sediment deposit. These values are compared in Figure 6.2. A good correlation is present: therefore this hypothesis is accepted.

Hypothesis 3:

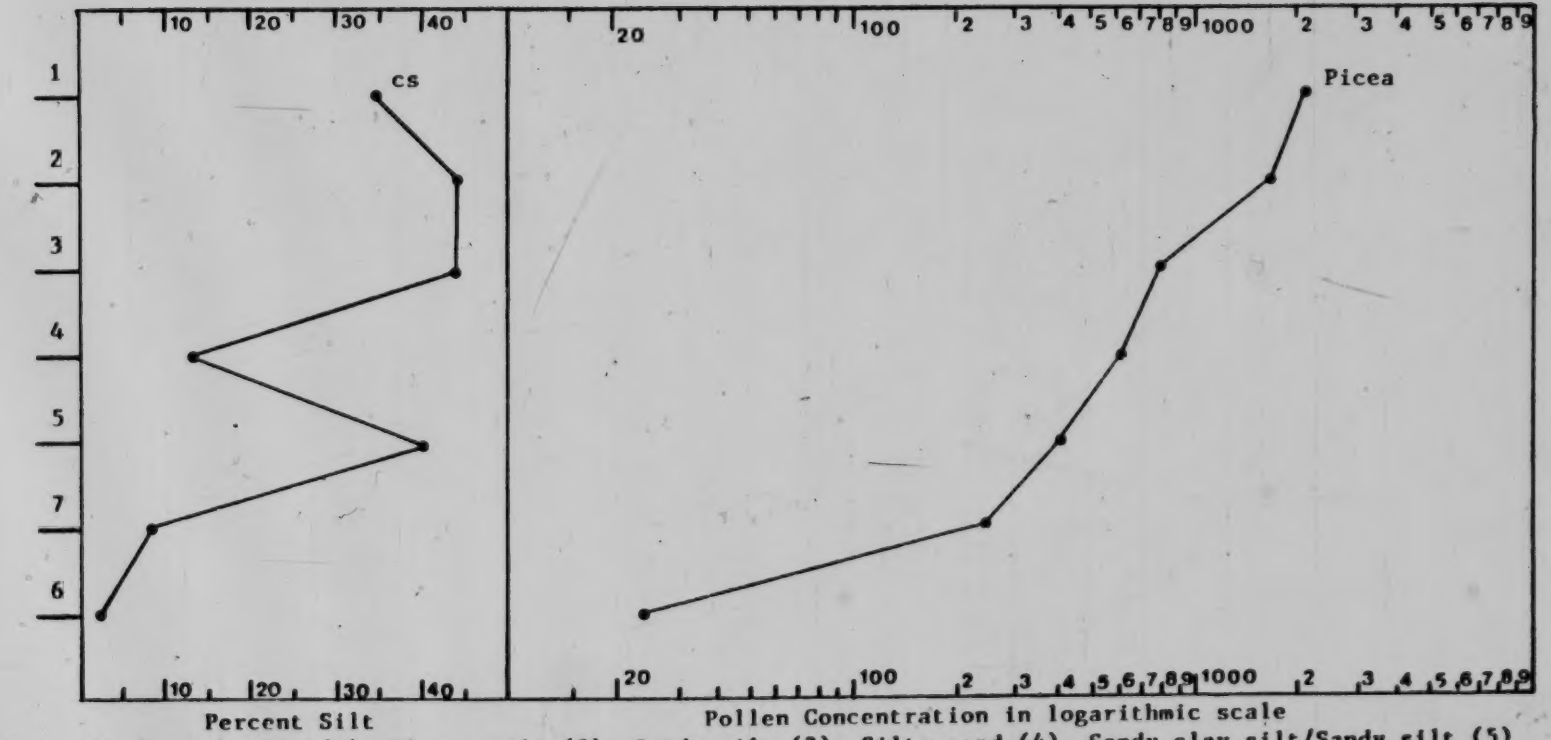
Betula pollen should become incorporated into the finer silt fraction of a suspension load during fluvial transport and should fall out of suspension along with that fraction during sediment deposition. Therefore, concentrations of *Betula* pollen may be related to the amount of fine silt within a sediment deposit. These values are compared on Figure 6.3. A good correlation is present: therefore this hypothesis is accepted.

Hypothesis 4:

Alnus pollen should become incorporated into the finer silt fraction of a suspension load during fluvial transport and should fall out of suspension along with that fraction during sediment deposition. Therefore, concentrations of *Alnus* pollen may be related to the amount of fine silt within a sediment deposit. These values are compared on Figure 6.4. A good correlation is present: therefore this hypothesis is accepted.

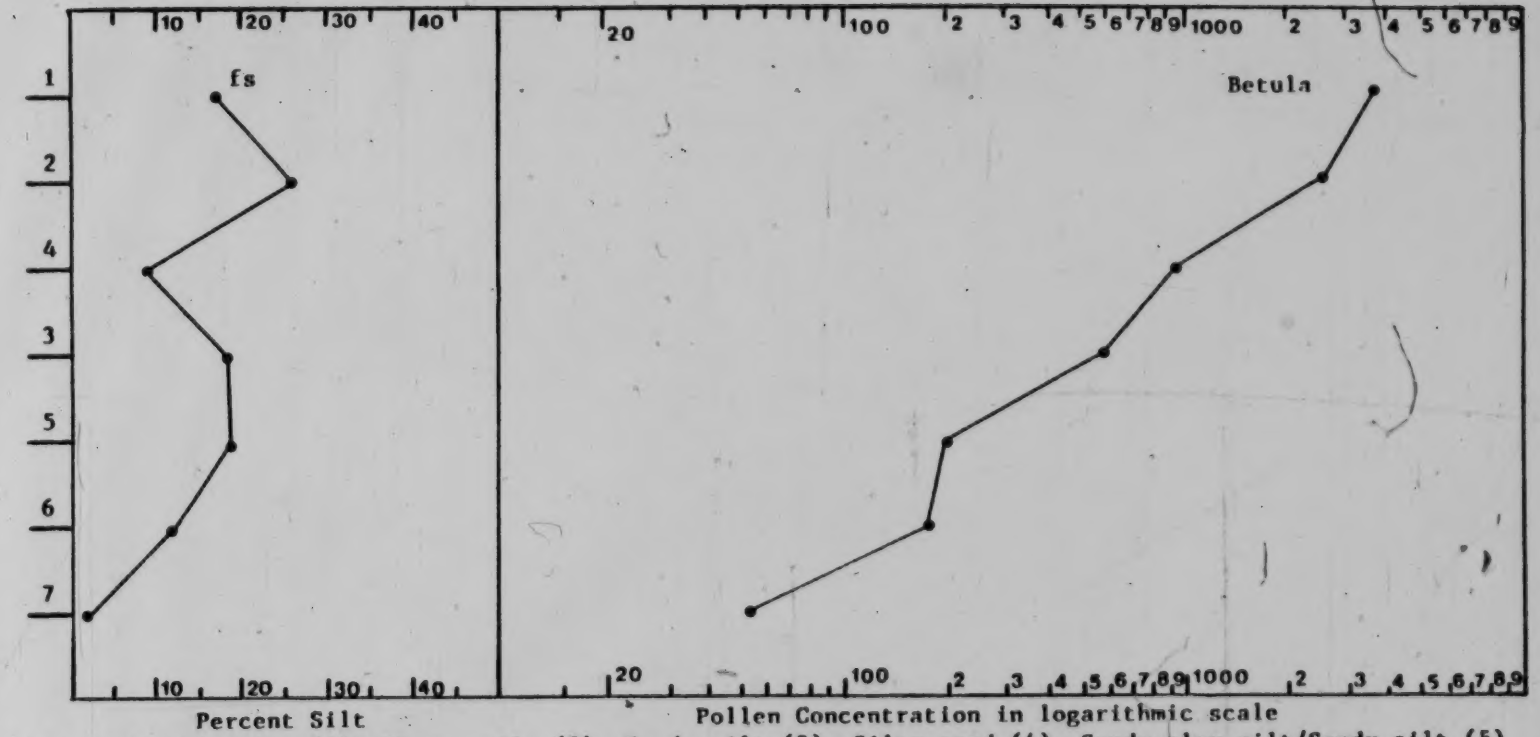
Hypothesis 5:

Ericaceae pollen should become incorporated into the coarser silt fraction of a suspension load during fluvial transport and should fall out of suspension along with that fraction during sediment deposition. Therefore, concentrations of Ericaceae pollen may be related to the amount of coarse silt within a sediment deposit. These vales are compared on Figure 6.5. A good correlation is present: therefore this hypothesis is accepted.



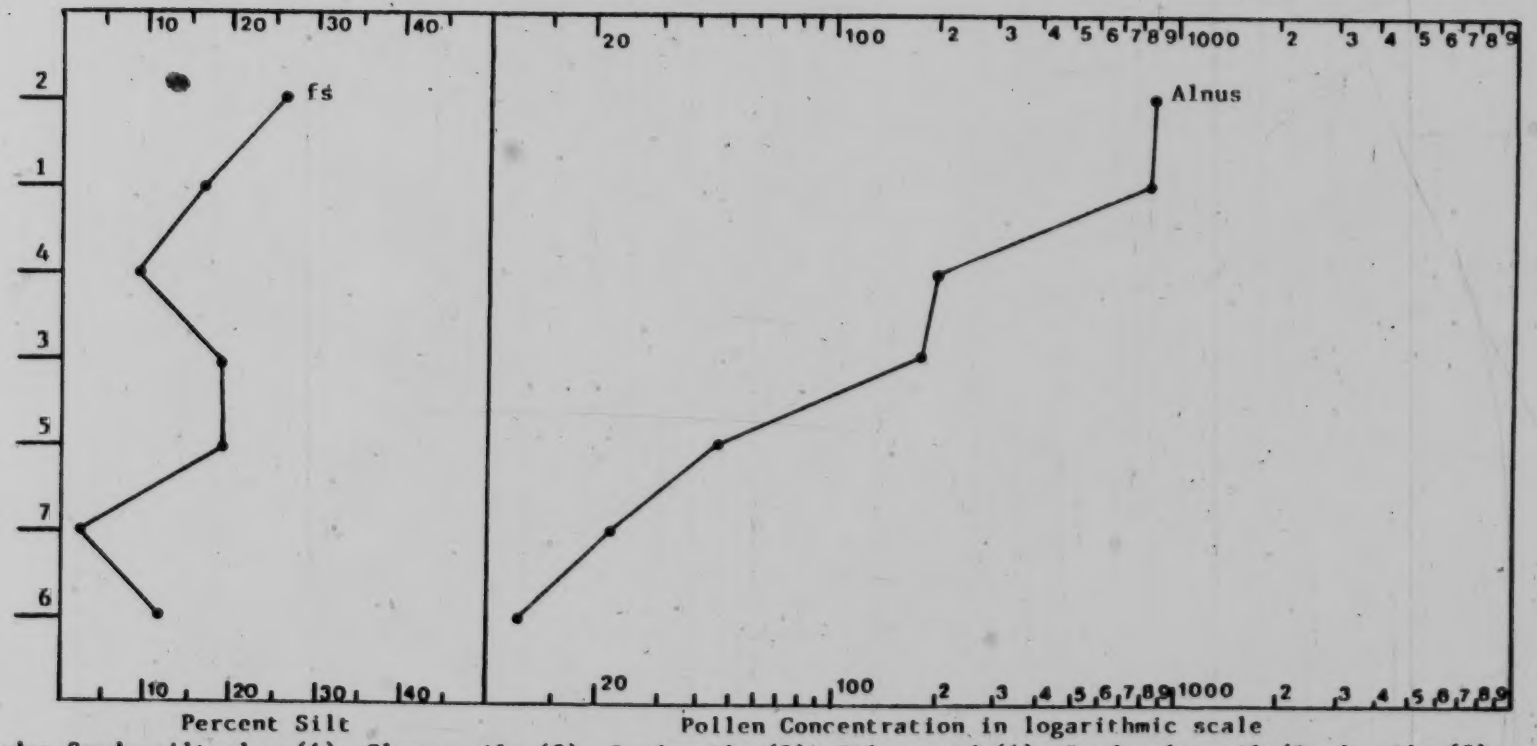
Code: Sandy silt clay (1), Clayey silt (2), Sandy silt (3), Silty sand (4), Sandy clay silt/Sandy silt (5) Clay (6), Sand (7); coarse silt (cs), fine silt (fs).

Figure 6.2: Picea pollen concentrations compared to coarse silt fraction within sediment categories



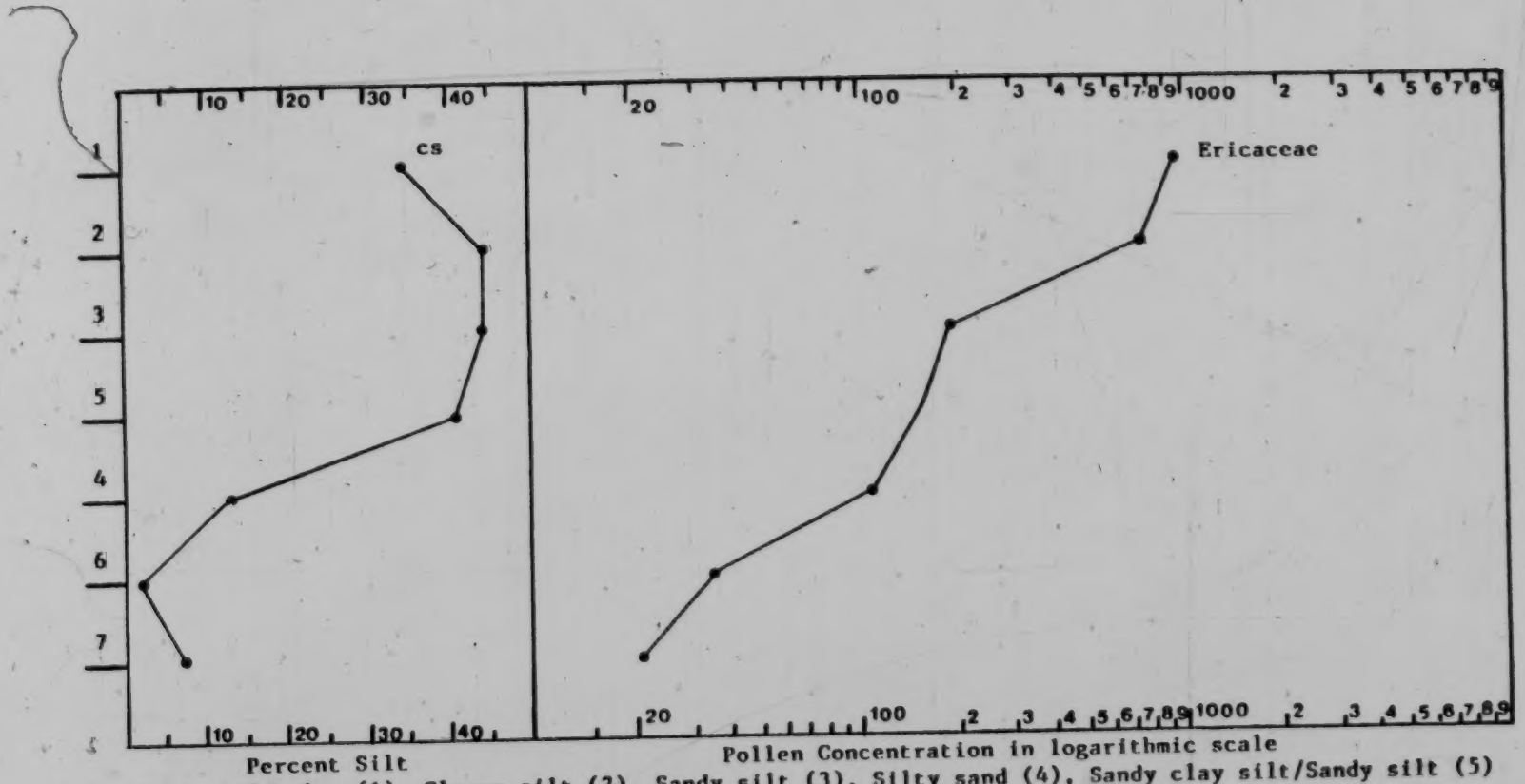
Code: Sandy silt clay (1), Clayey silt (2), Sandy silt (3), Silty sand (4), Sandy clay silt/Sandy silt (5) Clay (6), Sand (7); coarse silt (cs), fine silt (fs).

Figure 6.3: Betula pollen concentrations compared to fine silt fraction within sediment categories



Code: Sandy silt clay (1), Clayey silt (2), Sandy silt (3), Silty sand (4), Sandy clay silt/Sandy silt (5) Clay (6), Sand (7); coarse silt (cs), fine silt (fs).

Figure 6.4: Alnus pollen concentrations compared to fine silt fraction within sediment categories



Code: Sandy silt clay (1), Clayey silt (2), Sandy silt (3), Silty sand (4), Sandy clay silt/Sandy silt (5) Clay (6), Sand (7); coarse silt (cs), fine silt (fs).

Figure 6.5: Ericaceae pollen concentrations compared to coarse silt fraction within sediment categories

Hypothesis 6:

Gramineae pollen should become incorporated into the finer silt fraction of a suspension load during fluvial transport and should fall out of suspension along with that fraction during sediment deposition. Therefore, concentrations of Gramineae pollen may be related to the amount of fine silt within a sediment deposit. These values are compared on Figure 6.6. A good correlation is present: therefore this hypothesis is accepted.

Hypothesis 7:

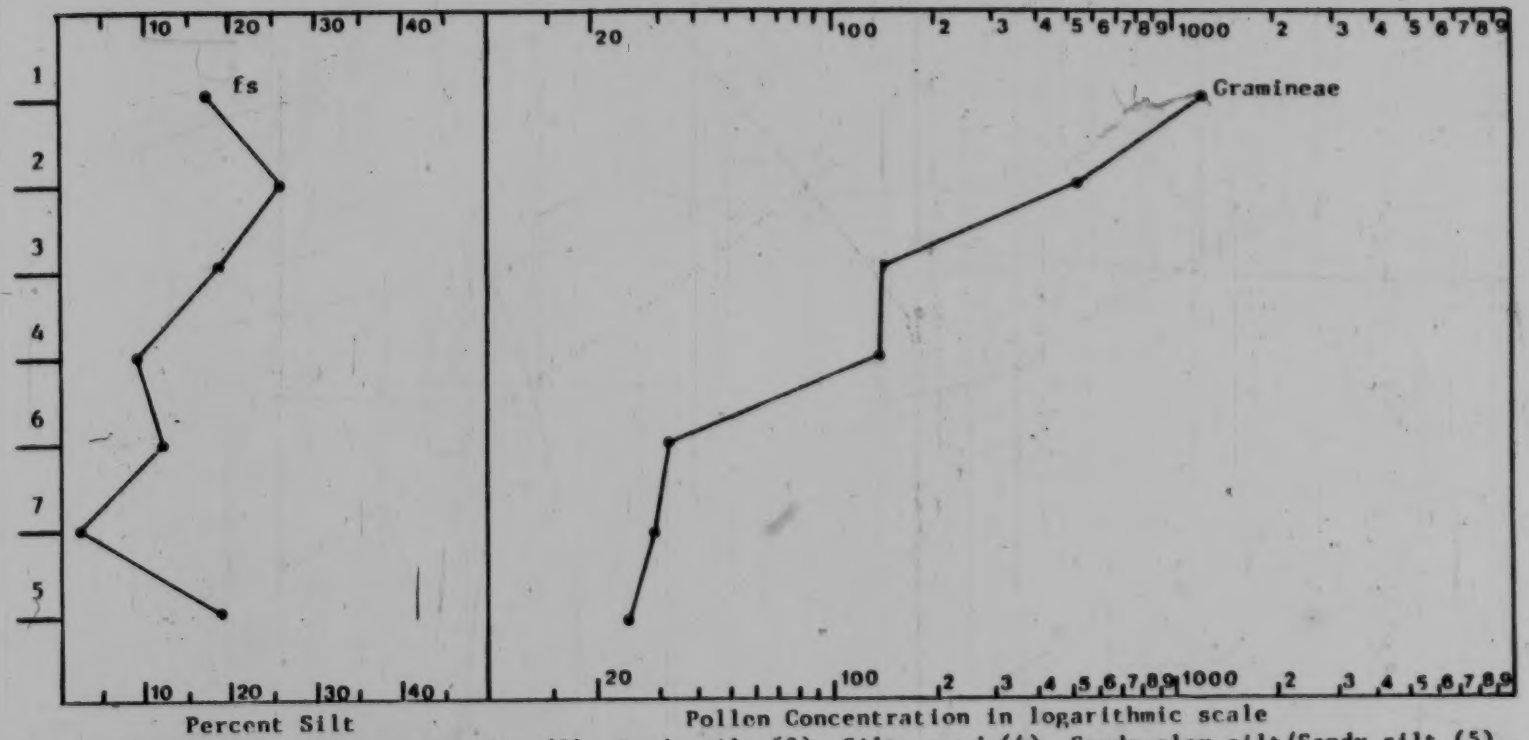
Cyperaceae pollen should become incorporated into the finer silt fraction of a suspension load during fluvial transport and should fall out of suspension along with that fraction during sediment deposition. Therefore concentrations of Cyperaceae pollen may be related to the amount of fine silt within a sediment deposit. These values are compared on Figure 6.7. A correlation is present: therefore this hypothesis is accepted.

Hypothesis 8:

Sphagnum spores should become incorporated into the coarser silt fraction of a suspension load during fluvial transport and should fall out of suspension along with that fraction during sediment deposition. Therefore, concentrations of *Sphagnum* spores may be related to the amount of coarse silt within a sediment deposit. These values are compared on Figure 6.8. An excellent correlation is present: therefore the hypothesis is accepted.

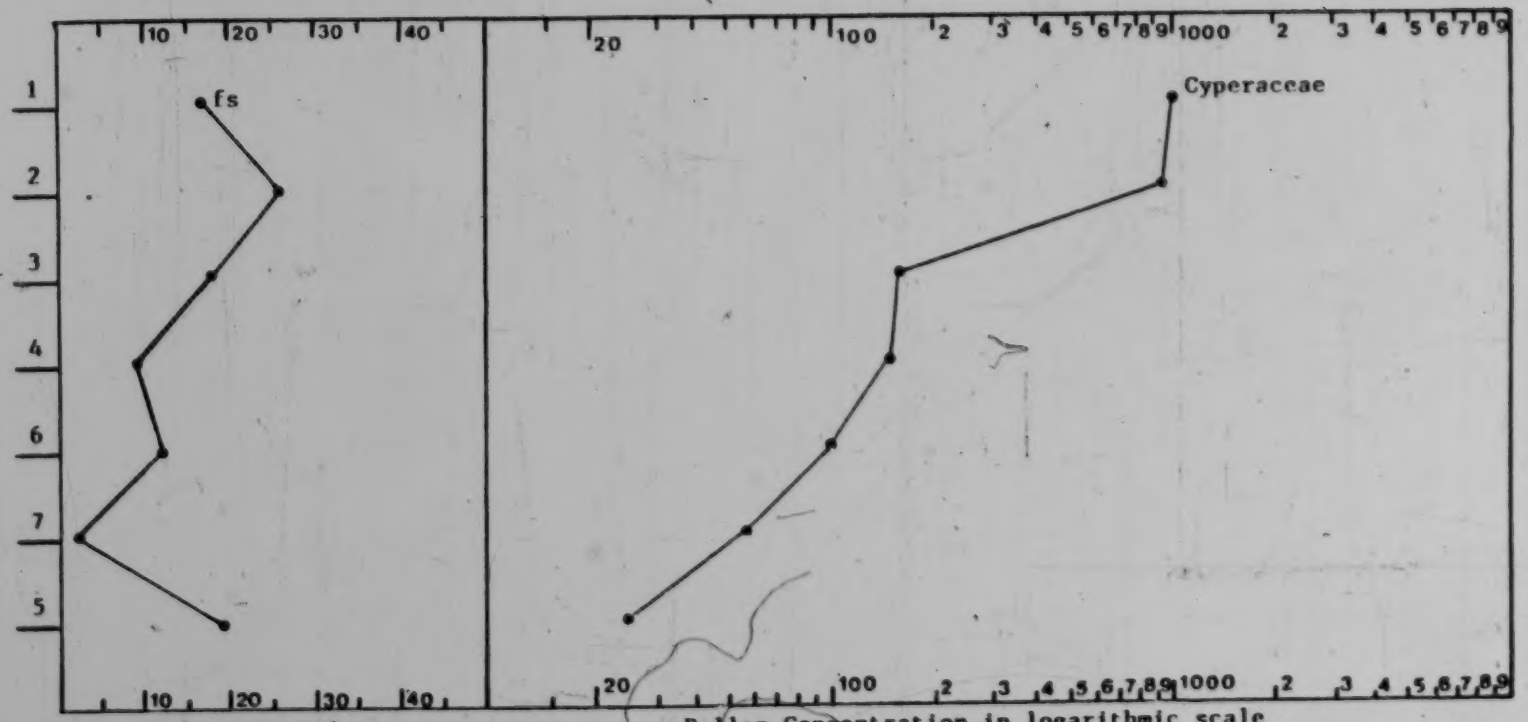
Discussion and General Comments

Sediment categories were found to be a useful means for comparing pollen variability and testing pollen taxon concentrations within sediments. For descriptive and comparitive purposes the use of these sediment categories is recommended in future studies in alluvial palynology. Data derived from the above tests indicate that there is a positive correlation between pollen concentrations and sediment size fractions. Also it appears likely that a stronger



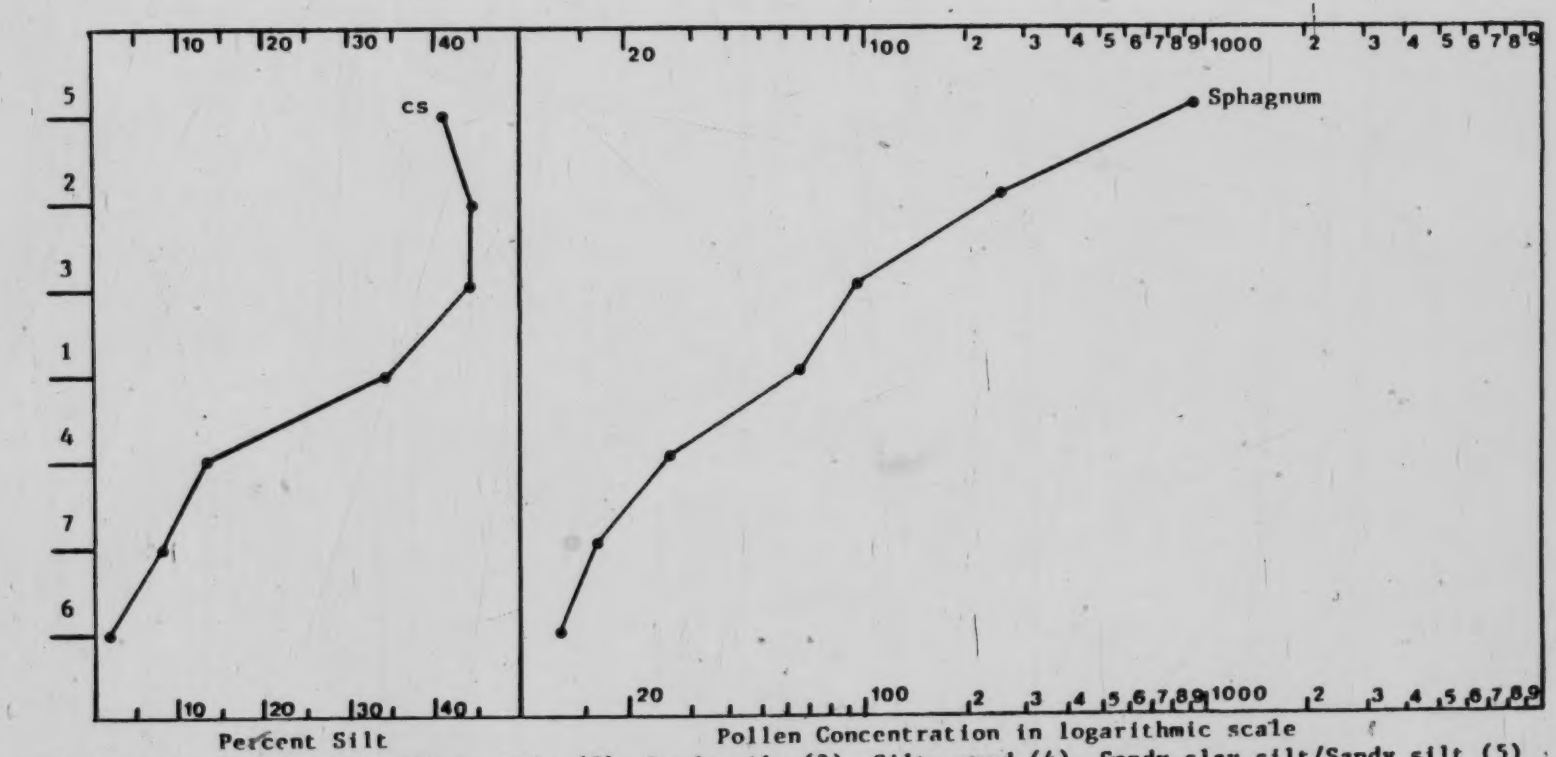
Code: Sandy silt clay (1), Clayey silt (2), Sandy silt (3), Silty sand (4), Sandy clay silt/Sandy silt (5) Clay (6), Sand (7); coarse silt (cs), fine silt (fs).

Figure 6.6: Gramineae pollen concentrations compared to fine silt fraction within sediment categories



Code: Sandy silt clay (1), Clayey silt (2), Sandy silt (3), Silty sand (4), Sandy clay silt/Sandy silt (5) Clay (6), Sand (7); coarse silt (cs), fine silt (fs).

Figure 6.7: Cyperaceae pollen concentrations compared to fine silt fraction within sediment categories



Code: Sandy silt clay (1), Clayey silt (2), Sandy silt (3), Silty sand (4), Sandy clay silt/Sandy silt (5) Clay (6), Sand (7); coarse silt (cs), fine silt (fs).

Figure 6.8: Sphagnum spore concentrations compared to coarse silt fraction within sediment categoties

correlation might have been achieved if a larger sediment data base had been available for testing. Further research, using a larger data set with equal frequencies of sediment categories, would be useful in defining taxon depositional characteristics within alluvial sediments.

B. Pollen Preservation Categories

Pollen preservation categories are listed on a relative percentage diagram (Figure 6.9). Two categories, Split/Perforated-good and Perforated-poor, contained so little pollen that they were excluded from the diagram. Well preserved pollen fall within the Normal-excellent/good and Folded-good categories. A third grouping of well preserved pollen is recorded within the Folded/Split/Perforatedgood category. Well preserved pollen recorded as Split-good is less significant, although values of 10 - 15% are present between 4.50m and 8.50m in Subdivisions 3d and 3e. Also values of ±5% are noted above 19.00m in Units 4 and 5. Folded/Split-good pollen is insignificant and only shows up in 5 samples. Perforated pollen contains the lowest frequencies amongst the well preserved categories.

The highest values of poorly preserved pollen are recorded as Folded-poor. Values up to ±45% are recorded mainly in sediments below 19.00m and in the Unit 6 sample. Two other important groupings of poorly preserved pollen include Folded/Split/Perforated-poor and Folded/Perforated-poor. Insignificant frequencies are noted within Split-poor and Folded/Split-poor. Discoloured pollen are most common above 19.00m, especially in Units 5 and 6 where frequencies of ± 5% occur.

Discussion and General Comments

The high frequencies of well preserved pollen indicates that the majority of pollen within the fossil pollen assemblage were not being subjected to adverse taphonomic agencies and in turn may reflect primary pollen deposition. The well preserved split and folded-split pollen grains no doubt reflect some transportation within a turbulent fluvial environment. It is interesting to note that the highest frequencies are present in sediments containing coarser clasts

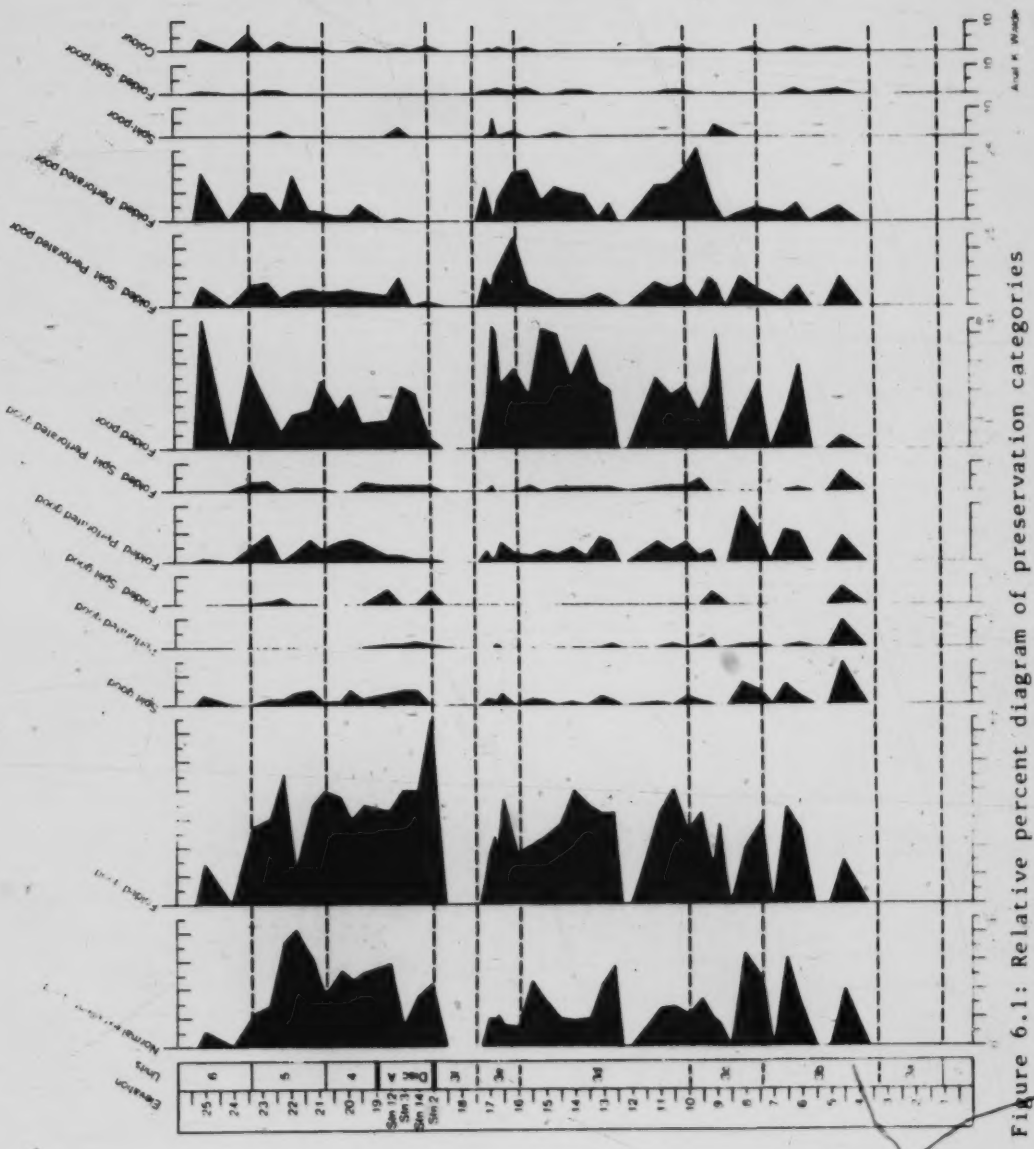


Figure 6.1: Relative percent diagram of preservation categories

(cf. Figure 4.7). Well preserved perforated and degraded perforated pollen indicates that corrosion was an important taphonomic factor thoughout the entire section, especially in sediments between 5.50m and 10.50m, 14.50m and 16.00m and in the upper Unit 4, 5 and 6 sediments. The degraded folded pollen values indicates that most samples may contain reworked pollen.

C. Preservation within Major Pollen and Spore Taxa

Preservation variability between major taxa are compared in Figure 6.10 (rear jacket). Except for *Betula*, all major taxa pollen and spores are predominately well preserved. *Betula* appears to be the primary contributor to the high frequencies of degraded pollen noted in Figure 6.9. Degraded *Picea* pollen is common between Subdivisions 3c and 3d and in the upper Unit 5 sediments. Ericaceae, Gramineae and Cyperaceae pollen have higher frequencies in Subdivision 3d, 3e and in the upper Unit 5 and 6 sediments. *Pediastrum* colonies have high frequencies of degradation in only the lower Unit 4 and Unit 6 sediments. Unidentified bisaccate pollen are significantly present in Unit 5. This corresponds to a similar high in degraded identifiable *Picea* pollen. Unidentifiable degraded Triporate remain relatively low in frequency throughout the section. Degraded Tricoloporate/Tricolpate, however, maintain consistently high values reaching ±28% in Unit 5. As previously discussed pre-Quaternary spores increase in frequency above 19.00m through Units 4, 5 and 6. The significance of this fact to the reconstruction of paleofluvial flow regimes and as possible indicators aof reconstructing previously unrecognized glacial conditions in this region will be discussed in Chapter 7.

In overview, data presented in Figure 6.10 are most significant to alluvial palynology. Except for *Betula* it is apparent that it would not make any difference in a vegetational reconstruction if the degraded portion of the pollen values among the major taxa were excluded or included from an analysis.

VII. Discussion and Paleoecological Conclusions

Paleoecological conclusions based on the sedimentological, palynological and taphonomic analyses are presented below according to unit designations. The paleoecological implication of redeposited Early Carboniferous spores present at the Locality 15 site is discussed. This is followed with a comparison of the Locality 15 pollen assemblage with other regional sites.

A. Unit 2(0m - 1.15m)

The exposed portion of this deposit is composed of non-pollen bearing compact sandy silt clays. Fossilized bones, wood fragments and fibrous organics are lacking. The sediments contain conchoidally fractured grains that lack subsequent erosional features. These data indicate reworked glacio-lacustrine sediments, which may have resulted from the draining of an early glacial impounding of the Old Crow Basin during Illinoian times (Hughes 1972, Morlan 1980). The conchoidally fractured lithics may have been fluvially transported in suspension from glacial outwash in the Richardson Mountains which were deposited within Unit 1 sediments and subsequently reworked into Unit 2 and the lower portions of Unit 3 (Subdivisions 3a & 3b). Alternatively, ice scouring of bottomset and bank deposits or bedrock during spring break-up may also be a source for these conchoidally fractured lithics. If the Unit 1 sediments contain large quantities of broken lithics it would appear that the most likely source would be glacial activity in the nearby mountains. A study of Unit 1 sediments is recommended to test this hypothesis. It has been suggested that concentrations of conchoidally fractured lithics may indicate the presence of archaeological sites (Fladmark 1982). Morlan (in Hughes et al.1981) utilizes the presence of conchoidally fractured microflakes to suggest that an archaeological site may be present at the Hungry Creek site, in sediments pre-dating the late Wisconsinan. A nearby site within the Eagle Plains was found to contain far higher concentrations of these microflakes, thus indicating natural causes vis-a-vis products of human activity. A point used in his arguement was that the sediments were fine grained, indicating deposition had occurred within a low energy environment. Such an environment could not be

responsible for such breakage. As an alternate suggestion, there is no reason that conchoidal breakage could not have occurred in a high energy environment elsewhere and that the microflakes were transported to the site of deposition within a suspension load without undergoing subsequent erosion.

B. Subdivision 3a(1.15m - 3.25m)

The mean sediment classification of this subdivision is silty clay sand. Contact with Unit 2 is disturbed and mixing of sediment is likely. Foreset bedding is present to ca. 2.0m where bedding becomes horizontal. Bedding becomes less defined in the upper portions. Concentrations of wood fragments, organic detritus and fossil bone including elements from *Mammuthus primigenius* are deposited along the disturbed Unit 2 contact. Sediments contain numerous conchoidally fractured quartz grains that do not exhibit subsequent erosional features. Individual tephra-like shards are present that have a X-ray diffraction signature similar to the Old Crow tephra (K Feldspar). Sediments were non-polleniferous.

The lower portions of Unit 3 are interpreted as early Sangamon in age (Hughes 1972, Morlan 1980). The fossil concentrations tends to confirm this interpretation. If the sediments are Sangamon in age it could be expected that they contain pollen. Because of their sterile nature plus the presence of concohoidally fractured silts and fine sands, this subdivision may be late Illinoian in age and deposited prior to the re-establishment of vegetation within the basin. Also, the presence of wood and other fossils may represent reworking of pre-Illinoian sediments. The presence of *Mammuthus primigenius* fossil remains does indicate a late-Quaternary time period for the deposit.

The possible presence of volcanic ash from the same source as the Old Crow tephra is intriguing as the main deposit is situated ca. 17.00m above this subdivision at other stations. If the the shards are tephra, then it appears likely that a previously unrecognized older ash-fall occurred within the basin. It is recommended that future studies of these lower sediments should include a search for the presence of tephra shards.

C. Subdivision 3b(3.35m - 7.45m)

The sediment mean for this subdivision is sandy clay silt. Deposition to ca. 6.00m is characterized by thin horizontal bedding containing peaty detritus. Wood fragments are common in the lower sediments. Above 6.00m the horizontal bedding planes become thicker. Sediments contain conchoidally fractured grains that exhibit subsequent erosional features.

Of the nine samples processed, four were polleniferous. The first pollen bearing sediment occurred at 4.50m. Pollen is well preserved but concentrations are relatively low. Major pollen and spore taxa represented, in descending order of frequency, include *Picea*, *Sphagnum*, Ericaceae, *Betula* and *Alnus*. *Picea* pollen decreases in frequency while *Sphagnum*, *Betula*, *Alnus* and Ericaceae increase with elevation. Broken and perforated pollen grains are present. The dominant unidentifiable pollen type is bisaccate. Increases in the tricolporate/tricolpate and undidentifiable grains become more common in the upper sediments. Herb taxa diversity increases with elevation. Low frequencies of Cretaceous spores are present in some samples.

The sediments contained fresh pollen at the time of deposition. A spruce forest is indicated. The forest cover probably contained open areas of poorly-drained *Sphagmun*-Ericaceous wetlands. *Betula* and *Alnus* were minor components of this community during initial sedimentation but later become more common. Sedges, grasses and *Artemisia* become established along with birch and alder. Areas of well drained substrate are indicated by these species. It appears that during the deposition of these sediments, the spruce cover was being modified as noted in these increased frequencies.

The low frequencies of degraded pollen and pre-Quaternary spores indicates that little contamination occurred due to rebedding of older pollen. The presence of broken pollen indicates some transportation occurred within a turbulent environment prior to deposition. Perforation on some pollen suggests deposition within a corrosive environment, e.g., biochemical oxidation. The low concentration of pollen in the lower deposits may suggest that sedimentation occurred prior to full pollen production while the non-pollen bearing sediments may reflect winter or very early spring deposition when little or no pollen was available.

D. Subdivision 3c(7.45m - 10.00m)

The textural mean is sandy silt/sandy clay silt. Bedding is well defined horizontal sediments containing fossilized wood fragments and/organic detritus. A morphological change in the sediment grains occurs from that noted in the preceding subdivision. Conchoidal breakage is not present. A minor disconformity is recognized in this subdivision at Stations 9 & 10 along which quantities of fossilized bone occur. Only one of five samples processed was non-pollen bearing. *Betula* continues to increase in frequency through the sediments while *Picea* and *Alnus* remain unchanged. Ericaceae pollen exhibit high frequencies in the lower sediments but decline in numbers with elevation. Cyperaceae pollen increase in the mid-sediments then decline. Gramininae continue to show a slight increase throughout and *Artemisia* maintains low frequencies in all samples. Frequencies of degraded identifiable pollen are higher in the upper sediments. The highest frequencies of unidentifiable pollen are noted in the tricolpoate/tricolpate category. Pre-Quaternary spores are present in low numbers in some samples. Herb taxa frequencies show a slight increase in the upper sediments.

A spruce-birch forest cover is indicated. Sedges appear to become a component of the ericaceous-peat wetlands during deposition of the sediments at ca. 9.00m. The presence of *Alnus* and *Artemisia* continues. A possible change in the environmental conditions occurs at ca. 9.00m as indicated by a sharp increase in degraded pollen grains, the change in species frequencies and the presence of the minor disconformity at Stations 9 and 10.

E. Subdivision 3d(10.00m - 16.00m)

The mean sediment classification of this subdivision is sandy clay silt. No visual breaks occur between the preceding and above lying subdivisions. Bedding is thicker in the lower portion and thinly laminated in the upper. Between ca. 11.50m and 13.50m foreset beds are present. Fine organic detritus and ostracod shells are common throughout. No fossilized bone or wood fragments are present. Sediment grains are highly eroded and conchoidal breakage is not present. Twelve samples were processed and only two were non-polleniferous. Pollen

concentrations are variable, ranging from very high to moderate. Preservation is slightly better than in the preceding subdivision. *Betula* pollen increase but are predominantly poorly preserved. *Picea* pollen decreases in frequency. Ericaeae, *Sphagnum* and Cyperaceae increase significantly in the upper sediments. Gramineae pollen exhibits both an encrease and a decrease though this subdivision. *Alnus* pollen is dominant in the lower sediments, declines through the mid-section. *Artemisia* pollen is present in low numbers in some samples. Degraded identifiable pollen is more prevalent in the upper sediments. Unidentifiable tricolporate/tricolpate grains are the most common degraded class within the subdivision. Unidentifiable triporate grains achieve their highest frequency for the entire section in the mid section sediments. Herb taxa diversity declines through the lower sediments, then increases in the mid-section but again undergoes a steady decrease throughout the remaining sediments. Pre-Quaternary spores are present in some samples but their numbers are lower than noted in the preceding subdivisions.

These sediments were apparently receiving substantial quantities of pollen throughout, suggesting that they were laid down during periods of pollen production and dispersal. The two sterile clayey silt sample, at 12.00m and 12.30m should be polleniferous. This suggests that these two samples were probably deposited during a non-pollenating time period.

A spruce-birch forest cover is suggested during sedimentation in the lower portion of this subdivision. A vegetational and/or environmental change may have began above 12.00m. Pollen data indicate that the forest cover became more open with increases in grasses, sedges and ericads. A possible change to forest-tundra may be interpreted from these data. During deposition of the upper sediments *Sphagnum* becomes an important component of this ground cover. Comparison between AP and NAP frequencies and their preservation characteristics also indicates that shrubs and herbs are more common than tree species during deposition of the upper sediments. The preservation of birch pollen is interesting in that they are predominantly poorly preserved in the upper sediments. This either reflects the identifiability of this taxon in a degraded condition or the sediments were obtaining quantities of reworked birch pollen from older deposits. The high values of birch pollen in the preceding subdivisions suggest that this

may be the case. The lower values of well-preserved birch pollen may also indicate that birch may have been declining in numbers at the expense of herb flora. In overview, a change in vegetation and climatic conditions within the Old Crow Basin apparently began during deposition of sediment above 12.00m.

F. Subdivision 3e(16.00m - 17.50m)

The sediment mean for Subdivision 3e is sandy clay silt. Bedding is characterized by compact horizontal peaty laminae. No fossilized wood or fauna fragments are present. Sediment grains are highly eroded. Seven samples were processed but only the uppermost two were non-polleniferous. Pollen concentrations are predominantly high except for the one sand sample at 16.76m. Pollen preservation is very poor, the second poorest for the section. *Picea*, and *Betula* both exhibit strong increases in frequencies. *Alnus*, Ericaceae, Gramineae, Cyperaceae and *Sphagnum* exhibit comparable frequencies. *Artemisia* is also present. *Pediastrum* colonies appear for the first time. Unidentifiable tricolporate/tricolpate grains continue to be the dominant class of degraded pollen. Bisaccate, triporate and unidentifiable pollen decline in frequency. Herb taxa diversity increases. Pre-Quaternary spores are absent. A slight increase in spruce and birch cover is indicated during deposition of the lower sediments. The presence of ericads, sedges and *Sphagnum* suggests that open poorly-drained areas are still a significant component of the flora community. In addition, the presence of small shallow ponds during spring near the site is suggested by the occurrence of *Pediastrum* colonies. The lack of pre-Quaternary spores indicates that the fluvial system was not eroding through older sediments. If reworked pollen grains were being deposited, they were of Quaternary provenience. The extremely high numbers of degraded pollen and changes in sediment type indicate that environmental conditions may have continued to deteriorate during deposition of these sediments. A rapid decline in the forest component is therefore suggested during deposition of the upper sediments. Periglacial conditions could be present in the basin during sediment deposition above 17.30m.

G. Subdivision 3f(17.50m - 19.00m)

The sediment mean for this subdivision is silt sized. The deposit is characterized by homogeneous compact non-fossiliferous sediments with little bedding visible. Some sediment grains are conchoidallly fractured and exhibit subsequent erosion. Deposits of Old Crow Tephra and ice wedge pseudomorphs are present along the bluff exposure at some stations. Contact between Units 3 and 4 is erosional. A paleosol (Bombin op cit.) was identified in the uppermost sediments at Station 2. Consequently, it appears that little sediment was removed from the top of Unit 3 through erosion. Two samples were processed and both were non-pollen bearing.

This subdivision probably represent a cross-section of a landsurface developed on a floodplain during periglacial conditions. A stable land surface probably existed for some duration following deposition of the upper sediments as recognized by the paleosol horizon at Station 2. Forest cover is unlikely. This subdivision probably dates to ca. ±100,000 years, as derived from the presence of the Old Crow Tephra.

H. Unit 4(19.00m - 20.80m)

The sediment mean for Unit 4 is clayey silt. Sediments are cross-bedded throughout. Imbricated fractured sediment grains are present. Concentrations of fossilized bones and peaty organics are present along the erosional contact with Unit 3. Eight polleniferous samples were processed. Pollen concentrations were moderate to very high. Pollen preservation was excellent, the highest for the entire section. The lower sediments are completely dominated by Gramineae and Cyperaceae pollen. They both exhibit a decline at ca. 20.00m but remain dominant throughout the upper sediments, especially Cyperaceae. *Picea* pollen increases significantly at ca. 20.00m. *Betula* pollen exhibits a steady increase throughout. *Alnus* and Ericaeae pollen is present in low frequencies. This contrasts greatly with their Unit 3 frequencies. *Artemisia* pollen is present throughout. Their frequencies are much high then in the Unit 3 sediments. *Sphagnum* spores are present in high numbers in the upper sediments. *Pediastrum* colonies

completely dominate the unit sediments. Unidentifiable grains dominate the lower sediments while degraded tricolporate/tricolpate class is very common in the upper sediments. Degraded triporate grains are present in low numbers throughout while degraded bisaccate grains exhibit low increases in the upper sediments. Herb taxa diversity achieves its highest frequency in this unit. Pre-Quaternary spores, identified as Early Carboniferous, are present in low frequencies. The presence of these spore is in marked contrast with the younger Cretaceous spores found in the older Unit 3 sediments.

This unit differs considerably from the underlying Units 3 deposits in terms of sedimentation, pollen assemblage and pollen preservation. A wet sedge-grass tundra is suggested during and possibly predating the initial deposition of Unit 4 sediments. Wet tundra conditions continues throughout the time of unit deposition. At ca. 20.00m, spruce appears to be re-established within the basin. Birch is probably present as a shrub. *Pediastrum* colonies are most indicative that shallow ponds were common in the area. High frequencies of *Artemisia* is indicative that open exposures on adjacent floodplains were present. The increased frequency of Carboniferous spores within Units 4, 5 and 6 may have significant implications in terms of paleofluvial drainage and climate within this part of the Yukon. It will be argued below their presence in the Locality 15 sediments indicate the possibility that the ancestral Porcupine River was diverted westward during deposition of Unit 4 sediments. This diversion was most likely caused by blockage of the McDougall Pass by advancing Laurentide glaciers on the east side of the Richardson Mountains.

I. Unit 5(20.80m - 23.40m)

Unit 5 sediment mean is clayey silt. The sand fraction is low. Bedding is very disturbed and ice wedge pseudomorphs are present at some stations. These ice wedge casts are much larger than those present along the Unit 4-3 erosional contact. Sediments are fossiliferous. Dates from this unit range between 41,000± 1,650 (GSC-2574) and 38,000±2,000 B.P.(GSC-2756).

All five samples processed were polleniferous. Pollen concentrations were moderate except for the uppermost which had a low concentration. Pollen preservation is good but slightly lower then that noted in Unit 4. *Picea* becomes the most dominant pollen type in the unit. *Betula, Sphagnum* and Cyperaceae are common. *Artemisia* pollen increases to its maximum sectional frequency. Gramineae, Ericaceae and *Alnus* are present in low numbers. *Pediastrum* colonies are present in the lower and upper sediments only. Unidentifiable tricolporate/tricolpate grains predominate in the lower sediments while degraded bisaccate and unidentifiable pollen grains are more common in the upper sediments. Degraded triporate grains are present in low numbers in all samples. Herb taxa diversity declines slightly. An extremely high influx of Early Carboniferous spores occurs above 23.00m.

A period of climatic deterioration is indicated during deposition of Unit 5 sediments. The vegetation appears to be a poorly-drained open spruce forest interspersed with sedge-*Sphagnum* meadows. The presence of small shallow ponds is indicated during deposition of the lower and upper sediments. Birch is common during deposition of the lower sediments but declines in importance during deposition of the upper sediments. The presence of grass and sage indicate that optimal well-drained open areas were also present. The influx of Early Carboniferous spores above 23.00m probable represents the inundation and creation of the the glacio-lacustrine lake caused by a dramatic increase in glacial discharge from the Richardson Mountains to the east and southeast. Consequently, full glacial conditions probably existed at this time within the basin.

J. Unit 6(23.40m - 27.00m, main facet)

Unit 6 sediments are characterized by non-polleniferous varved silty clays. Six samples were processed and only one was polleniferous. This clay pollen-bearing sample was located above 1.5m of sterile sediments. Pollen concentration was low and preservation very poor. The dominant pollen types, in descending order were: *Betula, Picea, Artemisia*, Gramineae, Cyperaceae and *Sphagnum*. Preservation is better in NAP than AP. Degraded

tricolporate/tricolpate is the most common unidentifiable pollen type. Unidentifiable bisaccate and triporate grains are present with very low frequencies. Herb taxa diversity declines from that noted in the preceding unit. Early Carboniferous spores are common.

The predominantly non-polleniferous nature of these sediments could indicate rapid infilling by sediment rich, glacial fed, streams in conjunction with a declining vegetation cover. The presence of well preserved pollen, although low in numbers, may indicate the possible occurrence of spruce, birch, sage, sedge and grass at optimum locations around the lake. The highly degraded nature of the pollen indicates either reworking of older sediments, post-depositional degradation due to harsh environmental conditions, or a combination of both. The presence of pre-Quaternary spores indicates the continuation of sedimentation from the same source that began with the initial deposition of Unit 4 sediments.

In overview, the interpretation presented above indicates that vegetation cover and environmental conditions progressed through a number of changes during the course of sediment deposition at Locality 15. Two fairly significant conclusions are derived from the data presented; a) an apparent change in the fluvial regime occurred above 19.00m (Disconformity A) that carried in quantities of Early Carboniferous spores from outside of the basin, indicating the establishment of a western drainage at a date far older then previously thought and b)High frequencies of *Picea* pollen indicate that spruce was a more dominant component of the floral community within the Old Crow Basin throughout the late Quaternary than previously thought. A discussion of these two observations are presented below.

K. Significance of Early Carboniferous Spores in Units 4, 5 and 6

As noted above, early Carboniferous spores appear in sediments stratigraphically above Disconformity A at 19.00m. They increase in frequency through Unit 4 and dominate the upper Unit 5 pollen and spore counts They are also a significant component of the Unit 6 fossil assemblage, as well. In contrast Unit 3 sediments contain younger Cretaceous spores.

It is of interest to note that large influxes of pre-Quaternary spores have been reported from sites containing late Pleistocene sediments within the region by other researchers: Lichti-Federovich (1973, 1974) at HH228; Cwynar (1979) at Hanging Lake; Schweger (pers.com.) at Hidden Bluff; McCort (1982) at Blue Fish site and Overden (1982) at Polybog. Although these spores remain unidentified it is most likely they are Carboniferous, as well.[6] In overview, at some point during the Wisconsinan, large numbers of Carboniferous spores began being transported and deposited within the Old Crow and Blue Fish Basins. It has been suggested that the most likely source for such large quantities of these spores would be the Fort Lake Shales of Early Carboniferous provenience, exposed within the Eagle Plains area (Figure 1.2).[7]

If the Fort Lake Shale deposits within the Eagle Plains are the source for these spores then it seems most likely that they were carried into the Old Crow Basin by fluvial transport. The main problem is that these spores start showing up in sediments immediately above Disconformity A, which is now thought to be ca. ±100,000 years old. This age is far too old to fit the hypothesis (Hughes et al. 1981) that westward diversion of water from the Richardson Mountains did not occur until McDougall Pass became permanently blocked by glacial ice and till during late wisconsian times. Assuming that these spores are from deposits within the Eagle Plains, then the initial westward diversion of the regional drainage systems must have occurred early. Research by Thorson and Dixon (1983) on the Porcupine River in Alaska below the Ramparts (Fig. 1.2) indicates that the Old Crow and Blue Fish Basins were repeatedly innundated by glacio-lacustine water and that overflow into Alaska via the Ramparts occurred at least three times during Wisconsinan times. Rampton (1982) reported glacial deposits along the north slope of the British Mountains and Buckland Hills which he attributed to a pre-late Wisconsinan glacial advance. The presence of these Carboniferous spores in Units 4, 5 and 6

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[6] Because of the paleoecological implication posed by the presence of these spores in the Old Crow and adjacent basins, a re-assessment and indentification of the spores mentioned in these resports is highly recommended.

[7] Personal discussion with Drs. O. Hughes, L. Norris and J. Utting, Institute of Sedimentary and Petroloeum Geology, Calgary, Alberta, in 1983.

sediments at Locality 15 supports the data presented in Thorson and Dixon (1983) and Rampton (1982). These spores can be considered as additional evidence for the existence of pre-late Wisconsinan glacial activity on the east side of the Richardson Mountains.

Cwynar (1979) suggests that pre-Quaternary spores in the lower sediments at Hanging Lake were derived from local bedrock. An alternative hypothesis is that they were obtained from periodic exposures of the glacial lake bed sediments that were rich in these spores. Wind activity over these exposed beds could easily pick up large quantities of these spores and redeposit them within the basin including Hanging Lake. The lower units of Polybog (Overden 1982) overly glacial lake sediments and contain pre-Quaternary spores which are most likely derived from these sediments. The remaining alluvial sites mentioned above appear to be stratigraphically comparable to Units 4, 5 and 6 at Locality 15. It is hypothesized that the same westward flowing fluvial system was responsible for depositing the reworked spores at all of these sites, including Locality 15.

L. Locality 15 Pollen Comparisons with Eastern Beringian Sites

The presence of *Picea* in eastern Beringia, especially during the late Pleistocene has been the subject of some discussion (Lichti-Federovich 1973, Cywnar 1979, Ritchie and Cywnar 1979, Cinq-Mars 1979). A striking feature of the Locality 15 fossil pollen assemblage (this thesis) is the high frequency of *Picea*. Within Unit 3, below 13.00m, Units 4 and 5, *Picea* percentages are higher than reported modern surface samples (Birks 1977, Cywnar 1980, Ritchie and Lichti-Federovich 1967) and from the initial pollen analysis of the Locality 15 sediments (Lichti-Federovich 1973).

Palynological data, presented here, is at some variance with that obtained by Lichti-Federovich (1973). She records lower sums for *Picea* as well as *Betula*, Ericaceae and *Artemisia* but higher sums for Gramineae, Cyperaceae and *Salix*. Comparable frequencies for *Alnus*, *Sphagnum* and Bryophytes were obtained. These discrepancies may reflect different laboratory processing techniques as she notes that her samples contained very little pollen

(Lichti-Federovich 1973:557).

Although the frequencies of the dominant AP taxa differ, similar trends are noted between 30ft - 60ft; 60ft - 70ft (Old Crow 5) and 9.00m - 17.50m; 19.00m - 21.00m in this thesis. She suggests that the *Picea* frequencies in the upper sediments were probably transported "from adjacent forest-tundra or forest, but it is unlikely that these arboreal elements occurred in vegetation of the lowlands" (Lithchi-Federovich 1973:562). Data presented here indicate that a spruce forest did in fact became re-established in the Old Crow Basin during deposition of Unit 4 and 5 sediments. Also high frequencies of Cyperaceae and Gramineae are recorded at 19.00m in this thesis and at ±60ft (Old Crow 5). This concurs with the the suggestion that climatic conditions were periglacial and a tundra vegetation was present prior to and during the initial deposition of Unit 4 sediments. Her highest frequency for *Artemisia*, between 60 - 70ft also corresponds with the section high obtained for this pollen type in Unit 5 (this thesis).

In summation, the main difference between the two pollen diagrams is the high frequencies of Gramineae and Cyperaceae above ±30ft indicating a tundra vegetation existed within the lowlands until inundation by glacial melt-water represented by Unit 6 sediments. Data in this thesis indicate a changing vegetation mosaic in the Old Crow Basin during this time period, i.e, boreal (Subdivision 3b &3c) to forest tundra (Subdivision 3d) to tundra (Unit 4, Disconformity A) to boreal forest (Upper Unit 4 sediments and Unit 5) and forest-tundra (Upper Unit 5 sediments).

Similar *Picea* frequencies as noted in the Locality 15 pollen assemblage have been recorded elsewhere. At Reid Lakes in Central Yukon, Schweger reports percentages of ± 50% for *Picea* (Hughes et al. 1981:342). At the Hungry Creek site (Hughes et al 1981), high frequencies of *Picea* are reported in sediments that may be of the same age as Units 4 and 5 at Locality 15. The presence of *Picea* is variable at other Beringian sites, e.g., Imurik Lake (Shackleton 1979), Koyukuk Ky-II (Schweger and Matthews n.d.), and HH228 (Big Bluff), (Lichti-Federovich (1967).

The Locality 15 fossil pollen assemblage in which *Picea* is the predominant component is most similar to the Holocene records from Lake George, above 3.00m (Ager 1975), Epiguruk I, Zone E IV (Schweger 1976) and Antifreeze Pond (Rampton 1971).

Based on the presence of the Old Crow tephra at Imuruk Lake (Shackleton 1979), Koyukuk Ky-II (Schweger & Matthews n.d.), HH228 (Lichti-Federovich 1974) and Locality 15 in this thesis, a regional comparison is permitted. Below the ash, tundra vegetation is indicated, above the ash, boreal components predominate. The return of a boreal forest into the Old Crow area is also indicated at the HH228 site from Zone (Lichti-Federovich 1974). Fewer spruce were apparently present in the southern part of the Blue Fish Basin because little *Picea* pollen was recorded at the Blue Fish site, Zone 4c - 4b (McCort 1982). A return to tundra conditions is again indicated at Imukiuk Lake, Zone 12, Koykuk KY-II, elevation 5m, HH228, Zone E and Locality 15, Unit 5 (uppermost sediments). This decline in forest cover to tundra conditions is also indicated at the Isabella site, Zone Ab/B boundary (Matthews 1974) and at Antifreeze Pond (Rampton 1971).

There is some evidence for the possible existence of spruce enclaves within eastern Beringia during late Wisconsinan glaciation. High frequencies of *Picea* pollen are reported at the Blue Fish section, Zone 4a and 3 (McCort 1982), Blue Fish Cave, Levels 13 - 26 (Cinq-Mars 1979), Hanging Lake, Zone HL1A 2B (Cywnar 1980); and Locality 15, Unit 6 in this thesis. It is interesting that the Hanging Lake lower sediments contain higher *Picea* frequencies during the tenure of the glacial lake within the Old Crow Basin then during the Holocene. The presence of high *Picea* frequencies and spruce macrofossils in these sediments await adequate explanation, and the possibility that spruce enclaves were present in the area during glacial conditions cannot be discounted even though current hypotheses exclude *Picea* from the flora community (Ritchie & Cywnar 1979, Cywnar 1979). Recently, Cywnar (1982) in re-assessing the Hanging Lake data does not rule out the possibility of spruce surviving within the basin during periglacial conditions.

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Appendix A

A. Part A

Trees and Large Shrubs

001: Bisaccate, undifferentiated
002: Bisaccate, body and bladder
003: *Picea*
004: *Picea*, bladder
005: *Picea*, body and bladder
006: *Pinus*
007: *Pinus*, body and bladder
008: *Abies*
009: *Tsuga heterophylla*
010: *Juniperus*
011: *Thuja*
012: *Beltula*
013: *Alnus*
014: *Myrica*
015: *Salix*
016: *Populus*
017: *Shepherdia canadensis*
018: *Elaegnus*
019: *Cornus stolonifera*
020: *Lonicera involucrata*
021: *Ostrya/Carpinus*
022: *Carya*
023: *Corylus*
024: *Pterocarya*
025: *Celtis* type
026: *Telia*
027: *Juglans* type
028: *Ulmus* type

Small Shrubs and Herbs: 100-100

100: *Cornus*
101: Ericaceae
102: Rosaceae, undifferentiated
103: *Rosa acicularis*
104: *Rubus chamaemorus*
105: *Rubus idaeus*
106: *Dryas/Rubus* type
107: *Amelanchier*
108: *Fragaria viriniana*
109: *Sanguisorba*
110: Caprifolliacaea, *Linnaea* type
111: Gramineae

112: Cyperaceae
113: Chenopodiaceae/*Amaranthus*
114: Compositae, Tubuliflorae High Spine
115: Compositae, Tubuliflorae Low Spine
116: Compositae, Liguliflorae
117: *Saussurea*
118: *Artemisia*
119: Caryophyllaceae
120: Cruciferae, undifferentiated
121: *Cardamine* type
122: Arabus type
123: Gentianaceae, *Gentiana* type
124: Labiatae, *Stachys* type
125: Labiatae, *Galeopsis* type
126: Labiatae, *Menta* type
127: Leguminosae, undifferentiated
128: Liliaceae, *Lloydia/Tofieldia* type
129: Ornagraceae, *Epilobium*
130: Orangraceae, *Ciraea*
131: Papaveraceae
132: Polemoniaceae, *Plox*
133: Polemoniaceae, *Polemonium*
134: Portulacaceae, *Claytonia*
135: Plantaginaceae, *Plantago*
136: Polygonaceae, undifferentiated
137: *P. bistorta* type
138: *P. amphibium/ persicaria* type
139: *P alaskanum* type
140: *P. aviculare/ achoreum* type
141: *P. convolvulus* type
142: *Erigonum* type
143: *Rumex/Oxyria* type
144: Primulaceae, *Androsace* type
145: Primulaceae, *Primula* type
146: Ranunculaceae, undifferentiateds
147: *Anemone*, tricolpate type
148: *Anemone*, pericolpate type
149: *Caltha* type
150: *Ranuncuus trichophyllus* type
151: *Thalictrum*
152: Rubiaceae, *Galium*
153: Saxifragaceae, undifferentiated
154: *S. aizoides/ tricuspidata/ oppositifolia* type
155: *S. nivalis/ stellaria* type
156: *Ribes*
157: Scrophulariaceae, undifferentiated
158: *Pedicularis* type
159: *Castilleja* type
160: *Lagotis* type
161: *Linaria* type
162: Umbelliferae, undifferentiated
163: Valerianaceae

Aquatics and Semi-Aquatics: 200-299

200: *Alisma*
201: *Hippuris*
202: Juncalaceae, *Luzula*
203: *Menyanthes*
204: *Myriophyllum*, undifferentiated
205: *Myriophyllum spicatum* type
206: *Myriophyllum exalbescens* type
207: *Nuphar*
208: *Potamogetum/Triglochin* type
209: *Sagittaria*
210: *Sparganium*
211: *Typha*
212: *Araceae, Arisema* type

Pterodophyta and Algae: 300-399

339: Lycopodiaceae, undifferentiated
300: *L. selago*
301: *L. annotinum*
302: *L. clavatum*
303: *Selaginella* type
304: *Sphagnum* type
305: *Isoetes* type
306: *Equisetum* type
307: *Botrychium* type
308: *Bteridium* type
309: *Dryopteris* type
350: Polypodiaceae, undifferentiated
310: Alete, undifferentiated
311: Alete, type 1
312: Alete, type 2
311: Alete, type 3
312: Alete, type 4
311: Alete, type 5
312: Alete, type 6 (Microfoveolatoporis type)
311: Alete, type 7
312: Alete, type 8

Pre-Quaternary Spores

314: *Murospora friendii* type
315: *Densosporites* sp.
316: *Costatoperforosporites* type
317: *Leiotriletes* type
318: *Waltzispora* type(?)
319: *Triquitrites* type(?)
320: *Deltoidospora* spp. or Leitriletes spp.

321: *Punctatisporites* type
322: *Monilospora* type
323: *Osmundaceae, Osmunda* type
324: *Verruosporites* type
325: *Waltzispora albertensis* type
326: Lycopodiaceae type(?)
327: *Murospora* spp.
328: Trilete, type 15
329: *Convolutispora* spp.
330: *Tripartites incisotilobus* sp.
340: *Cirratriradites* spp.
341: *Apiculatisporis spp.(?)*
342: *Aquilapollenites* type
343: *Circatricosporites* type
344: Trilete, type 22
345: Trilete, type 23
346: *Retriculatisporites* type
347: Trilete, type 25
348: *Anapiculatisporites* type
349: *Discernisporites micromanifestus* sp.(?)
360: Trilete type 28
361: *Anapiculatisporites* type(?)
362: Trilete, type 30
363: *Murospora* spp.
364: *Densoporites spitsbergensis*
365: *Densosporites anulatus* sp(?)
366: Trilete, type 34
367: Trilete, type 35
368: Trilete, type 36
369: Trilete, type 37
370: *Triparites* type
371: Trilete, type 39
372: Trilete, type 40
373: Trilete, type 41
374: Trilete, type 42
375: Trilete, type 43
376: Trilete, type 44
377: Trilete, type 45
378: Trilete, type 46
379: Trilete, type 47

Forms, Other: 400-499

400: Charcoal/Coal
401: Tephra (?)
402: Form 1
403: Form 2
404: Form 3
405: Form 4
406: Form 5
407: Form 6
408: Form 7

409: Form 8
410: Form 9
411: Form 10
412: Form 11
413: Form 12
414: Form 13
415: Form 14
416: Form 15
417: Form 16
418: Form 17
419: Form 18
420: Form 19
421: Form 20
422: Form 21
423: Form 22
424: Form 23
425: Form 24
426: Form 25
427: Form 26
428: Form 27
429: Form 28
430: Form 29
431: Form 30
432: Form 31
433: Form 32
434: Form 33
435: Form 34
436: Form 35

Unidentifiable Pollen and Other Palynomorphs: 500-599

500: Unidentifiable
501: Tricolporate/Trilcolpate
502: Tricolporate, unidentifiable
503: Periporate, unidentifiable
504: Stephanoporate, unidentifiable
505: Indeterminable
574: Unknown, triporate
575: Unknown, tricolporate
576: Unknown, palynomorph
577: Tetrad

B. Part B

Pollen Preservation Coding Index

Phentypic Categories

1: Normal
2: Folded(F), cf. Cushing (1966) 'crumpled'
3: Split(S), cf. Cushing (1966) 'broken'
4: Perforated(P), cf. Cushing (1966) 'corroded'
5: Folded/Split/Perforated(F/S/P)
6: Folded/Split(F/P)
7: Folded/Perforated(F/P)
8: Split/Perforated(S/P)

Exine Condition

1: Excellent
2: Good
3: Poor

C. Part C

Pollen Colouration

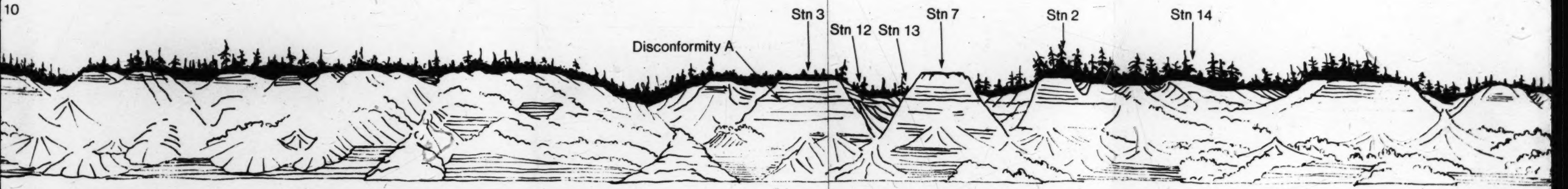
0: White, semi-translucent
1: 7.5YR 6/8, 7/8 (yellow-orange)
2: 7.5YR 2/3, 3/3 (very dark brown-dark brown)
3: 7.5YR 4/6 (brown)
4: 5YR 4/8, 5/8 (reddish brown-bright reddish brown)
5: 2.5YR 3/6, 4/8, 5/8 (dark reddish brown-reddish brown)
6: 10R 2/3, 4/8, 5/8 (very dark reddish brown-dark red-red)
7; Code 6 in folds, around perforations on grains coded 1
8: 2.5Y 5/3 (yellow gray)

Locality 15, Old Crow River, Yukon Territory

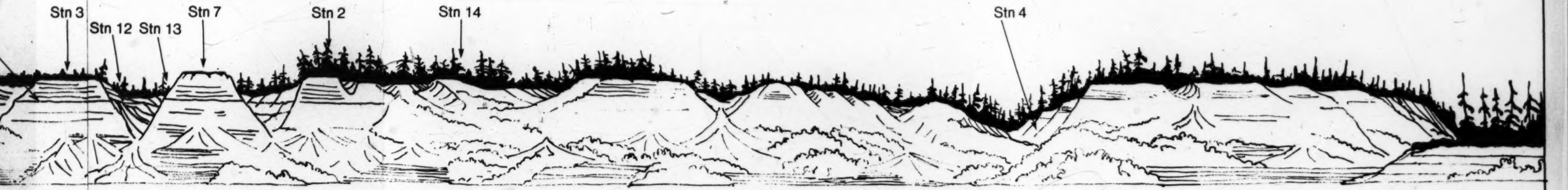
67° 51'N, 139° 48'W

Figure 2.1: Locality 15, Old Crow River Yukon Territory showing stations mentioned in the text , looking west.

10



in the text , looking west.


Stn 3
Stn 12
Stn 13
Stn 7
Stn 2
Stn 14
Stn 4
Old Crow River
Upstream

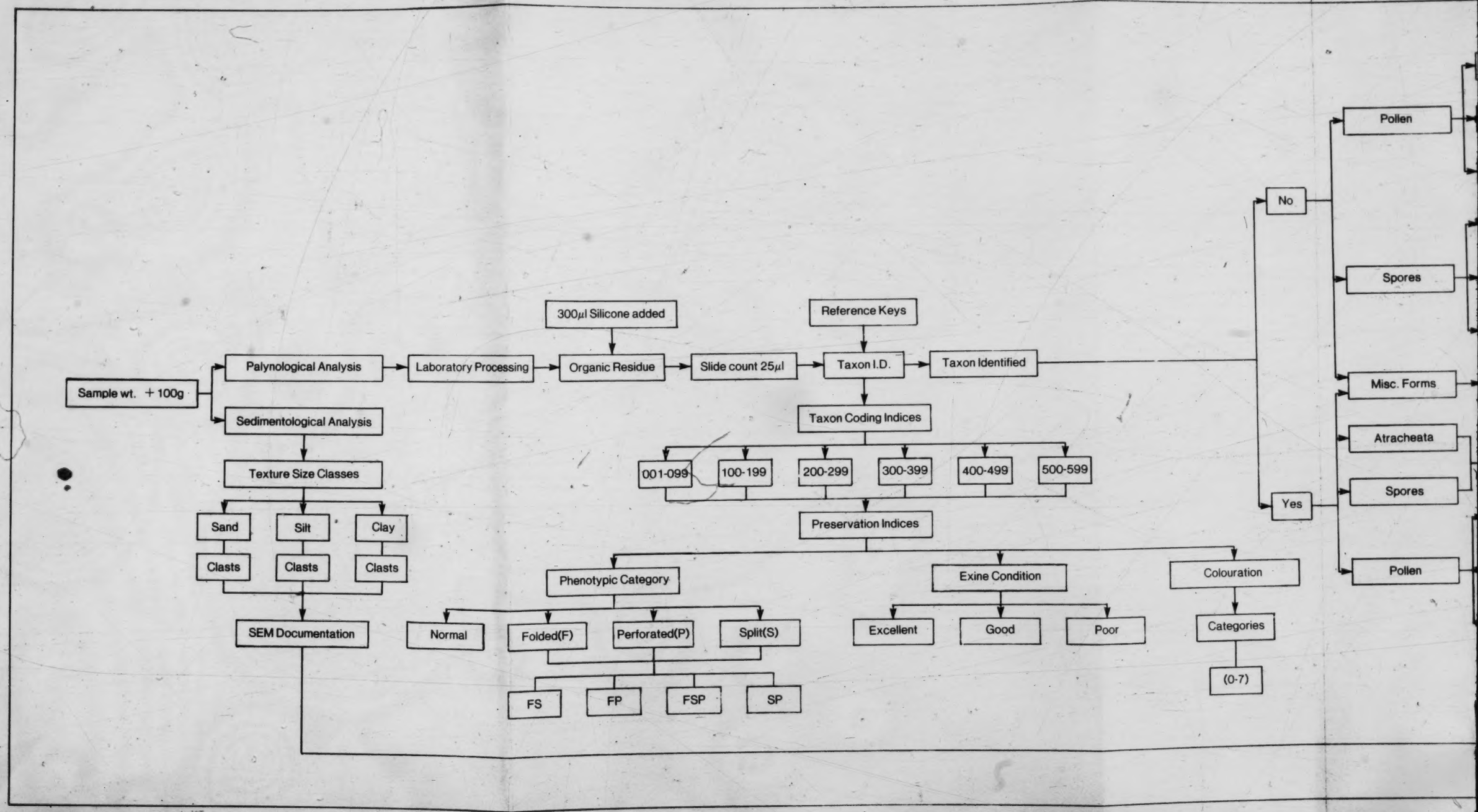
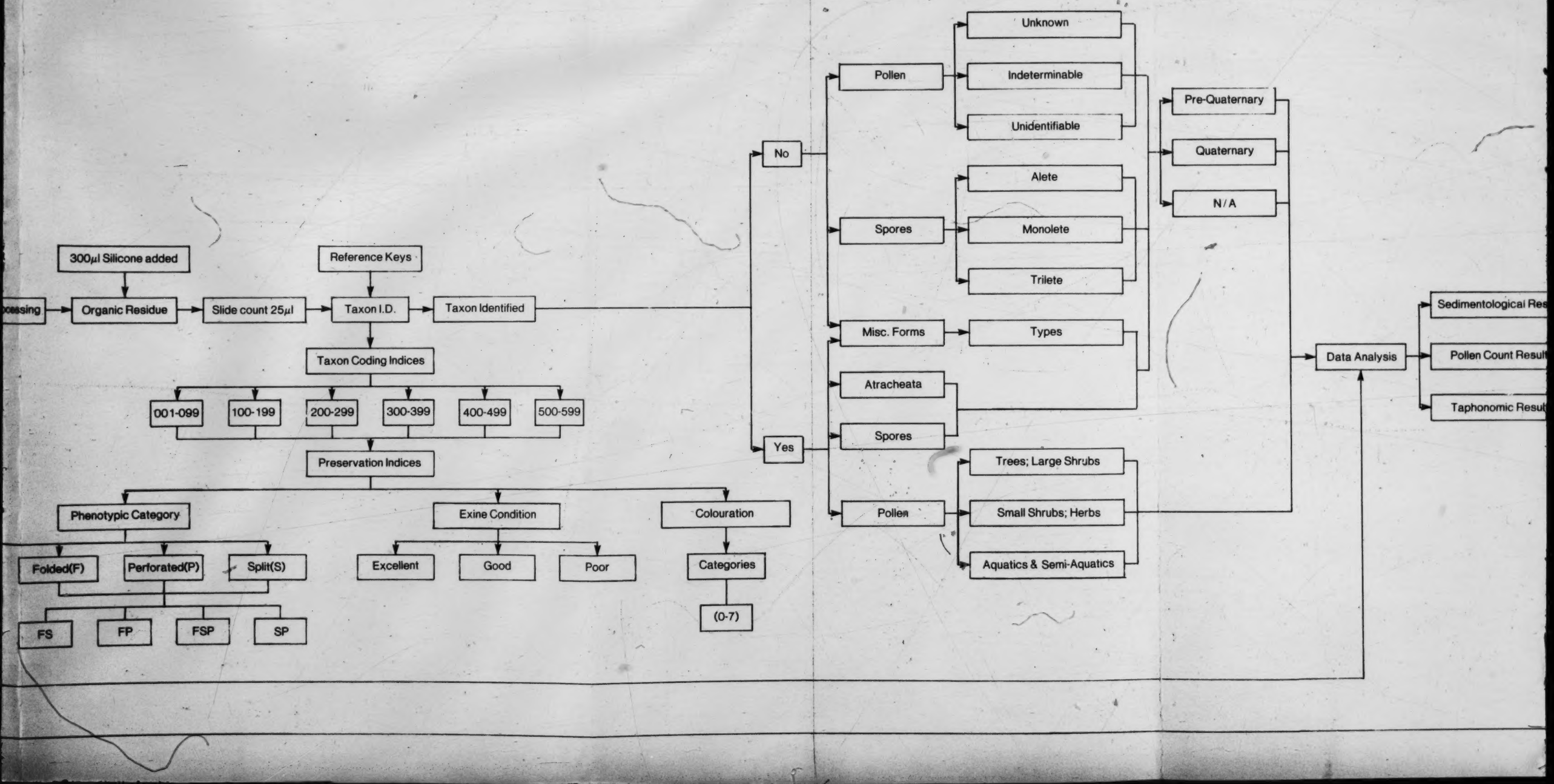
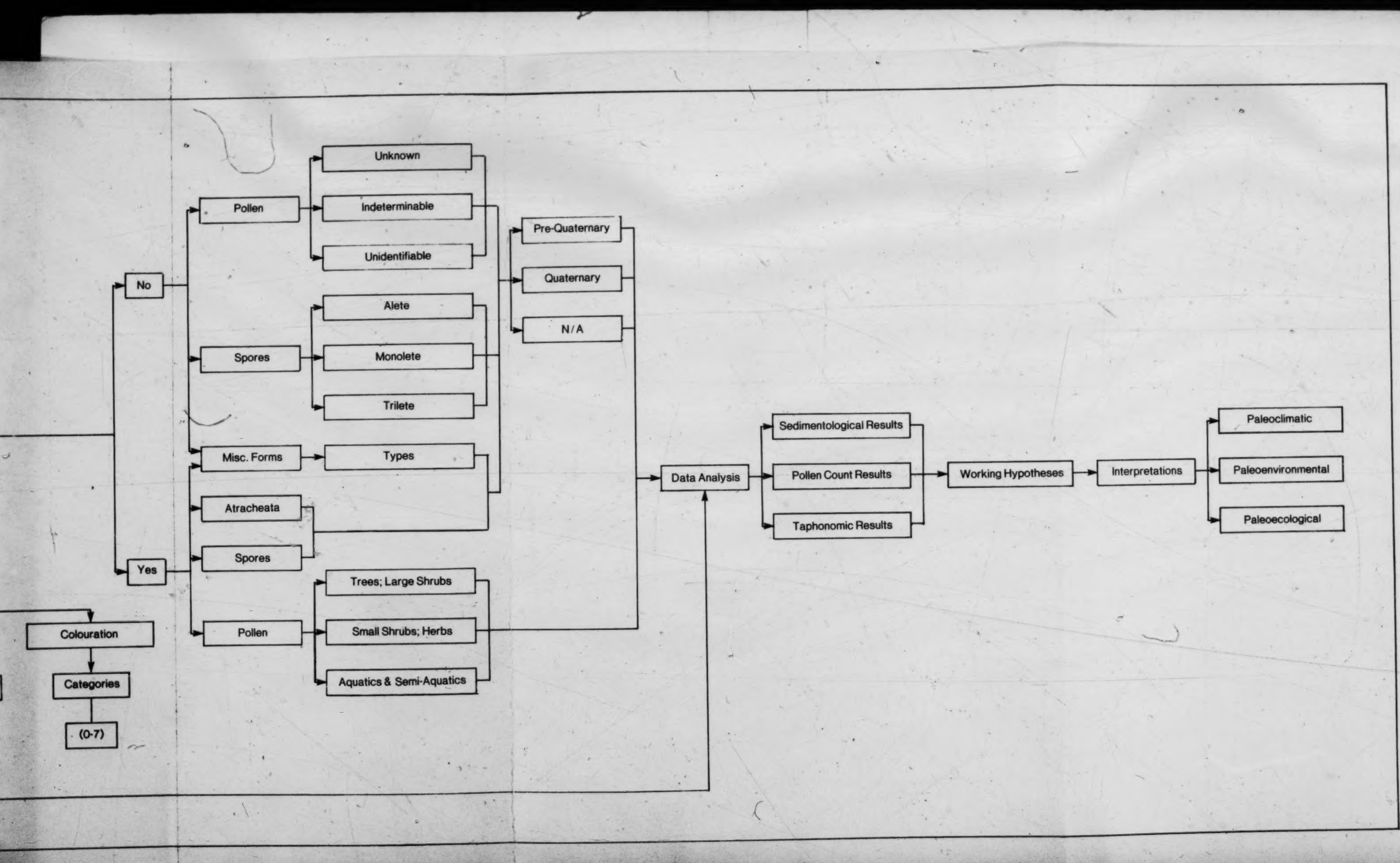


Figure 3. 1: Research Strategy Flow Chart.


300µl Silicone added
Organic Residue
Slide count 25µl
Taxon I.D.
Taxon Identified
Reference Keys
Taxon Coding Indices
001-099
100-199
200-299
300-399
400-499
500-599
Preservation Indices
Phenotypic Category
Folded(F)
Perforated(P)
Split(S)
FS
FP
FSP
SP
Exine Condition
Excellent
Good
Poor
Colouration
Categories
(0-7)
No
Yes
Pollen
Spores
Misc. Forms
Atracheata
Spores
Pollen
Unknown
Indeterminable
Unidentifiable
Alete
Monolete
Trilete
Types
Trees; Large Shrubs
Small Shrubs; Herbs
Aquatics & Semi-Aquatics
Pre-Quaternary
Quaternary
N/A
Data Analysis
Sedimentological Res
Pollen Count Result
Taphonomic Result


Unknown
Pollen
Indeterminable
Unidentifiable
Pre-Quaternary
No
Quaternary
Alete
N/A
Spores
Monolete
Trilete
Misc. Forms
Types
Atracheata
Spores
Yes
Trees; Large Shrubs
Pollen
Small Shrubs; Herbs
Aquatics & Semi-Aquatics
Colouration
Categories
(0-7)
Data Analysis
Sedimentological Results
Pollen Count Results
Taphonomic Results
Working Hypotheses
Interpretations
Paleoclimatic
Paleoenvironmental
Paleoecological

Sedimentological Analysis
Locality 15, Old Crow River, Yukon Territory
67° 51'N, 139° 48'W

Part A

Stratigraphic Positions of Features at Selected Stations

Stratigraphic Des

Retrogressive Thaw Flow Slide

Station 7

Station 9 (upper)

38,000 ± 2,000 B.P.

Station 3 (upper)

Station 4

41,000 ± 1,650 B.P.

Station 6

Station 13

Station 2

Disconformity A

Profile of main facet at Station 7

Erosional Gully

Station 9 (lower)

Station 10

Erosional Gully

Station 3 (lower)

Scale 1m

Water Level

Old Crow River

Stratigraphy (Stns 3 and 7)

Description

varved bedd
non fossilifer
bedding distur
ice wedge ca
organics fossil
crossbeddin
fossiliferous
ice wedge ca
compact little be
tephra intrus
bedding comp
peaty lamina
bedding lamin
fine organic de
cross beddi
ostracode
bedding par
fine organic de
fossiliferous
wood
bedding lamin
some cross be
thin peaty lam
shells throug
organic rich de
wood detritu
bedding not well
dipping bedding
disturbed fossi
compact no be

Elevation (meters)

*Clast Morphology Code: Sv(sphericity value

Figure 4.7: Sedimentological analysis of Locality 15 deposits.

Part A

...ions of Features at Selected Stations

Retrogressive Thaw Flow Slide

Station 7

Station 4

W E

41,000 ± 1,650 B.P.

Station 2

S N

i.

h.

E

Gully

c.

Station 3 (lower)

Scale 1m

Part B

Stratigraphic Description and Clast Morphology Stratigraphy

Stratigraphy (Strns 3 and 7)	Description	Units	Clast Morphology*	Mean Textural % per Unit
	varved bedding non fossiliferous	6	Sv=(.73-.85) Rv=(.5-.6) C=(c,e)	Silty clay (2-48-50)
	bedding disturbed ice wedge casts organics fossiliferous	5	Sv= (.73-.83; .83-.85) Rv=(.4-.5; .5-.6) C=(c,f,e)	Clayey silt (4-71-25)
	crossbedding fossiliferous ice wedge casts	4	Sv=(.73-.77) Rv=(.2-.3) C=(c,i,f)	Clayey silt (14-65-21)
	compact little bedding tephra intrusions	3f	Sv=(.83-.85) Rv=(.3-.4) C=(c,e)	Silt (0-82-18)
	bedding compact peaty laminae	3e	Sv=(.73-.77) Rv=(.2) C=(e*,Sp)	Sandy clay silt (28-53-19)
	bedding laminated fine organic detritus cross bedding ostracods	3d	Sv= (.91-.95; .57-.69) Rv=(.1-.3) C=(e*,Sd,Sp)	Sandy clay silt (21-60-19)
	bedding parallel fine organic detritus fossiliferous wood	3c	Sv=(.91-.97) Rv=(.4-.5-; .9) C=(f,Sd,Sp)	Sandy silt/ Sandy clay silt (36-49-15)
	bedding laminated some cross bedding thin peaty laminae shells throughout organic rich detritus wood detritus	3b	Sv=(.71-.75) Rv=(.3-.4) C=(c,e,,Sd,Sp)	Sandy clay silt (30-52-18)
	bedding not well defined dipping bedding planes disturbed fossiliferous	3a	Sv=(.75-.77) Rv=(.1-.3) C=(c*,m*,f,Sd,Sp)	Silty clay sand (46-35-19)
	compact no bedding	2	Sv=(.75-.77)Rv= (.1-.3)C=(c,Sd,Sp)	Sandy silt clay (18-39-43)

Elevation (meters)

Part C

Clast Percent Frec

Sand (13%) Silt (55%) Clay (32%)

Coarse Sand(>0<1 phi) .2%

Medium Sand(>1<2phi) 1%

Fine Sand (>2<3 phi) 4%

Very Fine Sand (>3<4 phi) 8%

Coarse Silt (>4<5 phi) 15%

0 100 5 30 60 70

*Clast Morphology Code: Sv(sphericity value), Rv(Roundness value), C(Clasts), c(conchoidal breakage), i(imbricated breakage), e(edges eroded), f(edges not eroded), m(microblades, flakes), *(very common), Sd(Solution diagenesis), Sp(Silica precipitation)

Part B

Description and Clast Morphology Stratigraphy

Units	Clast Morphology	Mean Textural % per Unit
6	Sv=(.73-.85) Rv=(.5-.6) C=(c,e)	Silty clay (2-48-50)
5	Sv=(.73-.83; .83-.85) Rv=(.4-.5; .5-.6) C=(c,f,e)	Clayey silt (4-71-25)
4	Sv=(.73-.77) Rv=(.2-.3) C=(c,l,f)	Clayey silt (14-65-21)
3f	Sv=(.83-.85) Rv=(.3-.4) C=(c,e)	Silt (0-82-18)
3e	Sv=(.73-.77) Rv=(.2) C=(e*,Sp)	Sandy clay silt (28-53-19)
3d	Sv=(.91-.95; .57-.69) Rv=(.1-.3) C=(e*,Sd,Sp)	Sandy clay silt (21-60-19)
3c	Sv=(.91-.97) Rv=(.4-.5-; .9) C=(f,Sd,Sp)	Sandy silt/ Sandy clay silt (36-49-15)
3b	Sv=(.71-.75) Rv=(.3-.4) C=(c,e,,Sd,Sp)	Sandy clay silt (30-52-18)
3a	Sv=(.75-.77) Rv=(.1-.3) C=(c*,m*,f,Sd,Sp)	Silty clay sand (46-35-19)
2	Sv=(.75-.77) Rv=(.1-.3) C=(c,Sd,Sp)	Sandy silt clay (18-39-43)

Part C

Clast Percent Frequencies

Sand (13%) Silt (55%) Clay (32%)

Coarse Sand (>0<1 phi) .2%

Medium Sand (>1<2phi) 1%

Fine Sand (>2<3 phi) 4%

Very Fine Sand (>3<4 phi) 8%

Coarse Silt (>4<5 phi) 15%

Medium Silt (>5<6 phi) 19%

Fine Silt (>6<7 phi) 11%

Very Fine Silt (>7<8 phi) 10%

Coarse Clay (>8<9 phi) 7%

Fine Clay (>9 phi) 25%

Elevation (meters)

0 100 5 30 60 70 40 60 30 30 20 75

26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

), Rv(Roundness value), C(Clasts), c(conchoidal breakage), l(imbricated breakage), e(edges eroded), f(edges not eroded), m(microblades, flakes), *(very common), Sd(Solution diagenesis), Sp(Silica precipitation)

Anal. K. Walde

Locality 15, Old Crow River, Yukon Territory, Pollen Percentage Diagram 67° 51'N, 139° 48'W 67°

Anal. K. Walde

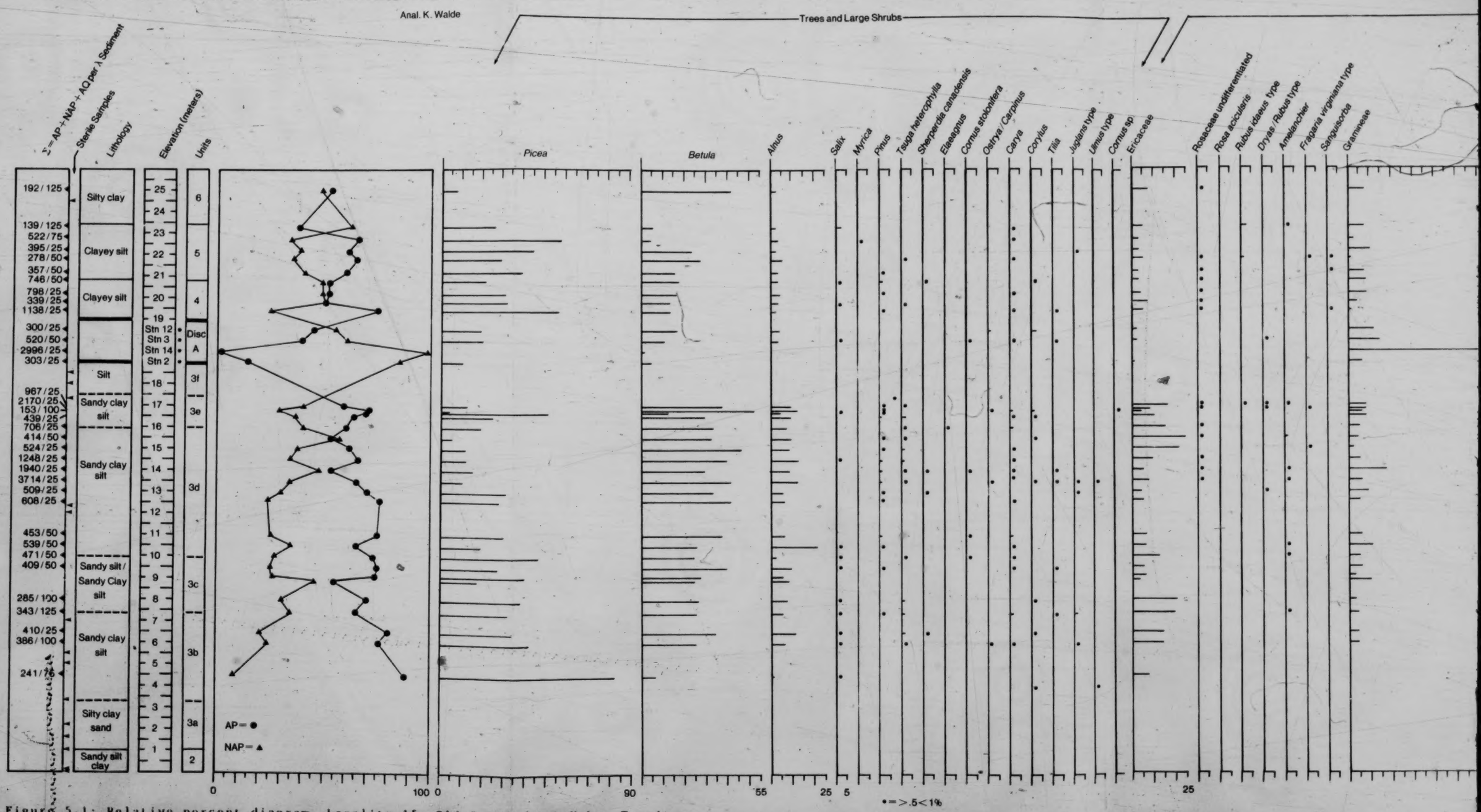


Figure 5.1: Relative percent diagram, Locality 15, Old Crow Basin, Yukon Territory

Small Shrubs and Herbs

Ulmus type
Cornus sp.
Ericaceae
Rosaceae undifferentiated
Rosa acicularis
Rubus idaeus type
Dryas / Rubus type
Amelanchier
Fragaria virginiana type
Sanguisorba
Gramineae
Cyperaceae
Chenopodiaceae / Am
Tubuliflorae h.s.
Tubuliflorae l.s.
Liguliflorae
Saussurea
Artemisia
Caryophyllaceae
Cruciferae undifferentiated
Cardamine type
Arabis type
Gentiana type
Galeopsis type
Mentha type
Leguminosae
Lloydia / Tofieldia type
Epilobium
Circaea
Papaveraceae
Phlox
Polemonium
Plantago sp.
Polygonaceae undifferentiated
P. bistorta type
P. amphibium / persicaria type
P. aviculare / achoreum type
Rumex / Oxyria type
Ranunculaceae undifferentiated
Anemone tricolpate type
Anemone pericolpate type
Caltha type
R. trichophyllus type
Thalictrum
Galium
Saxifragaceae undifferentiated
S. aizoides / tricuspidata type
S. nivalis / stellaris type
Ribes
Scrophulariaceae undifferentiated
Castilleja type
Umbelliferae undifferentiated
Valeriana
Menyanthes
Myriophyllum undiffer
M. spicatum

25
70
80
15
10

Aquatics and Semi-Aquatics

Pteridophyta

Bryophyta

Undifferntiated Spores

Atracheata

Unidentifiable

Ranunculaceae undifferentiated

Ranunculaceae tricolpate type

Axemone / pericolpate type

Caltha type

R. trichophyllus type

Thalictrum

Gallium

Saxifragaceae undifferentiated

S. azoides / tricuspidata type

S. mixalis / stellaris type

Ribes

Scrophulariaceae undifferentiated

Castilleja type

Umbelliferae undifferentiated

Valeriana

Menyanthes

Myriophyllum undifferentiated

M. spicatum

Nuphar

Potamogeton / Triglochin type

Sparganium

Typha

Ariseama

Unknowns

L. selago

L. annotinum

L. clavatum

Lycopodium undifferentiated

Selaginella type

Isoetes

Equisetum

Botrychium type

Pteridium type

Dryopteris type

Sphagnum

Trilete undifferentiated

Monolete undifferentiated

Alete undifferentiated

Botryococcus

Pediastrum

Bisaccate

Triporate

Tricolporate / Tricolpate

Periporate

Stephanoporate

Unidentifiable

Indeterminate

In Sum ← → Sums = ΣP plus individual taxon

15 75 35 55 55 25 10 20 20

Bryophyta
Undifferntiated Spores
Atracheata
Unidentifiable
Dryopteris type
Sphagnum
Trilete undifferentiated
Monolete undifferentiated
Alete undifferentiated
Botryococcus
Pediastrum
Bisaccate
Triporate
Tricolporate / Tricolpate
Periporate
Stephanoporate
Unidentifiable
Indeterminable
Pre-Quaternary spores
Charcoal / Coal
Other
Units
Elevation (meters)
6
5
4
Disc A
3f
3e
3c
3b
2
Stn 12
Stn 3
Stn 14
Stn 2
65
15
75
35
55
55
25
10
20
20
10
95
95
50

Pollen Preservation Percentage Diagram of Major Pollen and Spores, Locality 15, Old Crow R., Yukon Territory. 67° 51'N, 139° 48'W

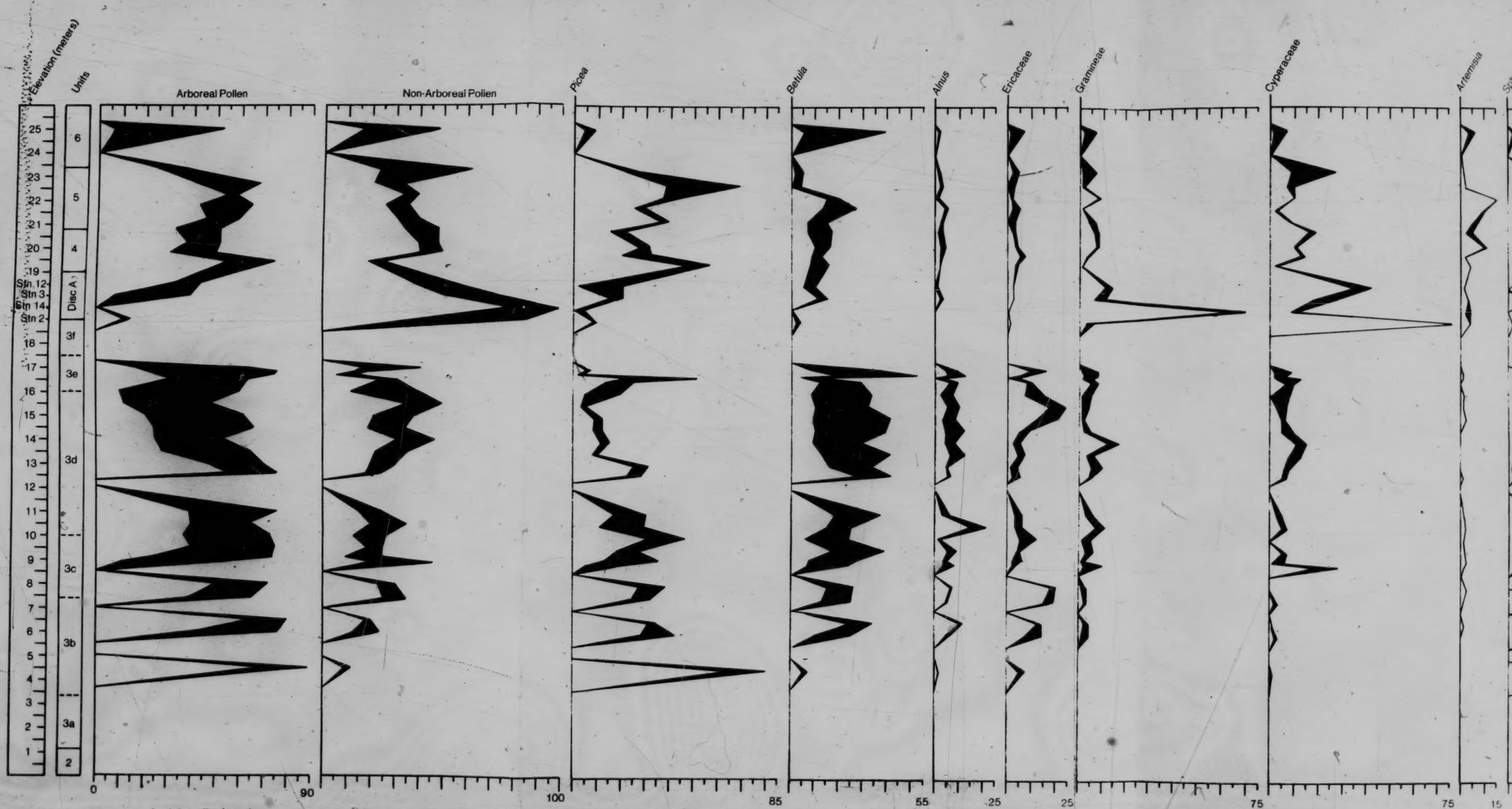


Figure 6.10: Relative percent diagram showing preservation ratios between well preserved and degraded categories of major pollen and spores. (white = well preserved, black = degraded)

139° 48'W

Ericaceae

Gramineae

Cyperaceae

Artemisia

Sphagnum

Pediastrum

Bisaccate

Triporate

Tricolporate / Tricolpate

Unidentifiable

NAP species diversity

Pre-Quaternary Spores

Units

Elevation

6

5

4

Disc A

3f

3e

3d

3c

3b

3a

2

Stn 12
Stn 3
Stn 14
Stn 2

25 25 75 75 15 75 80 25 10 20 20 30 95

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